Towards the Development of an Enhanced Recovery After Surgery Protocol for Elective Spine Surgery

By © Ryan David Greene

A Dissertation submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of

Doctor of Philosophy in Clinical Epidemiology, Faculty of Medicine

Memorial University of Newfoundland

May 2025

St. John's Newfoundland and Labrador

Abstract

Patients who receive spine surgery are subject to significant pain and disability following surgery. Following surgery, length of stay (LoS) is mutually problematic for patients and healthcare systems alike, as each day in hospital increases a patient's risk for adverse events and also represents significant financial burden for healthcare systems. Enhanced recovery after surgery (ERAS) protocols have been shown to be able to reduce LoS without increasing patient risk for re-admission to hospital. While ERAS protocols are well established in many surgical fields, ERAS is relatively novel in spine.

This dissertation used a mixed methods approach to develop an ERAS protocol for elective spine surgery at the QEII hospital in Halifax, Nova Scotia. A protocol was developed alongside an expert in enhanced recovery and stakeholders who provide care for spine surgery patients. Following this, a systematic review was performed to examine the efficacy of ERAS in spine, observing a reduction in LoS by 1 day after implementing an ERAS protocol. However, most studies included were subject to serious risk of bias due to confounding.

Locally, we wanted to identify what factors most frequently prevent spine surgery patients from being discharged from hospital. Issues related to mobilization, urinary retention and pain management were the most common reasons patients remained in hospital. By targeting these issues through an ERAS protocol, LoS could be reduced.

Lastly, patient education was studied through both a qualitative approach with patients with lived experience with surgery, as well as through a review of the literature and throughout Canada to identify how other surgical sites provide spine ERAS education. A

series of discussion groups covered how education could optimally be provided. Patients reported a strong preference for personalized education, however, were open to a multimodal approach to education delivery due to the difficulty of providing personalized education. In the literature, few studies elucidated what ERAS education entailed, or how it was even provided. In Canada, only the Vancouver General Hospital was identified to have a spine ERAS program and used a multimodal approach to education. They provided education via online booklets and in person classroom-style sessions.

General Summary

Recovery from spine surgery is known to be challenging regarding both pain management and morbidity. Patients who remain in hospital have an increased risk of poor outcomes, such as infection and represent a large financial burden to hospitals. Protocols aimed at expediting the recovery process, referred to as enhanced recovery after surgery (ERAS), have been shown to be effective in many surgical fields. These protocols typically show benefit through a reduction in length of stay, without compromising quality of care or increasing risk for re-admission to hospital. Currently, there are no established guidelines for spine surgery.

This thesis sought to develop an ERAS protocol for elective spine procedures at the QEII hospital in Halifax, Nova Scotia. To do so, we initially involved all stakeholders who participate in the circle of care for spine surgery patients. Throughout these meetings, we identified key components of an ERAS protocol that we could deliver, such as early mobilization and reduced fasting. Following this, a systematic review and meta-analysis was performed, which found that while all studies in spine surgery and ERAS show a reduction in length of stay, the quality of these studies was poor. Following this work, an audit was conducted at the QEII to determine what factors most commonly keep spine surgery patients in hospital following surgery. Through this study, it was observed that issues related to mobilization and urinary retention most commonly kept patients in hospital.

Lastly, two studies focused on patient education were conducted. The first study was a patient engagement initiative, where patients with a lived experience with surgery

discussed their experiences with surgical education and their education preferences. These patients communicated that while personalized educational programs would be ideal, multiple education delivery methods were acceptable given the challenges of providing personalized education programs to each patient. A systematic review of the literature also sought to determine how spine ERAS educational programs were delivered and what content was included. However, no studies reported what material was provided in their education, and only a few reported how they delivered education. One program in Canada provided detailed education regarding delivery of content and what content was included.

Acknowledgements

I am grateful to many people who have mentored or supported me throughout my time at Memorial between my Master's and Doctorate. To start, I would like to thank my supervisor, Dr. Amanda Hall for her support, guidance, and supervision over the past several years. Your knowledge, mentorship and kindness made this degree an incredible learning experience, and I appreciate the time I had learning from you. I'd also like to thank Dr. Holly Etchegary. Holly has been an excellent mentor and contributed significantly to my education, having supervised me for both my master's and PhD. I'm fortunate to have had so many great mentors during my time at Memorial.

At Dalhousie University, I would like to thank my supervisor, Dr. Sean Christie. Since meeting Sean in 2019, he has been an advocate for my academic success from the start. I am appreciative of Sean's guidance and mentorship, and I look forward to seeing where our future research projects will go.

Personally, this degree has been an effort that I was privileged to have many close family members and friends who supported me over the years. I'd like to thank my wife, Emma, for all of her love and support over these past several years. I first met Emma when I moved to St. John's in 2016 when we both lived at the battery and were pursuing our master's degrees. So Memorial and St. John's will always be an important place for us. During this degree, my wife and I purchased our first home, got married and welcomed our first baby. This degree was a team effort, and I relied on her to support me through this. I don't think it's cliché to say that it would be hard to imagine this degree being completed without you. To my daughter, Julia, who has brought so much joy while I was

finishing the writing of this thesis, I hope I can foster the same love for education and learning in you that your mom and I have. Next, I'd like to thank my parents, Lynn and David, for always encouraging my educational pursuits. Lastly, I'd like to acknowledge my many friends and colleagues I've met over the years during my studies in Clinical Epidemiology, as well as my friends outside of school; you know who you are.

I would also like to acknowledge NL Support for funding my scholarship over the last three years of my degree.

Dedication:

I would like to dedicate this thesis to the memory of my grandparents, Duncan, and Nellie Greene. I wish you could have been here to see this accomplishment.

Table of Contents

List of Tables

List of Figures

List of Abbreviations

ACDF: Anterior cervical discectomy and fusion

ALIF: Anterior lumbar interbody fusion

ASA: American society of anesthesiologists

BMI: Body mass index

CHO: Carbohydrate

CHX: Chlorhexidine gluconate

CI: Confidence interval

CSF: Cerebrospinal fluid

CSORN: Canadian spine outcomes research network

D+F: Decompression and fusion

ERAS: Enhanced recovery after surgery

GRADE: Grading recommendations, assessment, development and evaluations

GRIPP2: Guidance for Reporting Involvement of Patients and Public

IAP2: International Association for Public Participation

LBP: Low back pain

LLIF: Lateral lumbar interbody fusion

LoS: Length of stay

MIS: Minimally invasive surgery

NICE: National Institute for Health and Care Excellence

ODI: Oswestry Disability Index

OR: Odds ratio

OT: Occupational therapist

PACU: Post-anesthesia care unit

PCA: Patient controlled analgesia

PEM: Patient educational material

PICO: Population, inclusion, control/comparator and outcome(s)

PLIF: Posterior lumbar interbody fusion

POUR: Post-op urinary residual

PRESS: Peer review of electronic search strategies

PRISMA: Preferred reporting items for systematic reviews and meta-analyses

PT: Physiotherapist

QALY: Quality adjusted life year

QEII: Queen Elizabeth the Second

QI: Quality improvement

QUADAS: Quality assessment of diagnostic accuracy studies

RCT: Randomized controlled trial

RN: Registered nurse

RoB: Risk of bias

ROBINS-I: Risk of bias in non-randomized studies-of interventions

SPOR: Strategy for patient-oriented research

SRMA: Systematic review and meta-analysis

SRQR: Standards for reporting qualitative research

STROBE: Standards for reporting for observational studies

TCPS2: Tri-Council Policy Statement 2

TIDierR: Template for intervention description and replication

TLIF: Transforaminal lumbar interbody fusion

TRIC: Translating research into care

UBA: Uncontrolled before and after

UTI: Urinary tract infection

VAS: Visual analogue scale

List of Appendices

Chapter 1 : Introduction

Diseases of the Spine

The spine can be subject to a variety of diseases and pathologies, such as diseases due to trauma, deformity of the spine (e.g., scoliosis or ankylosing spondylitis), cancers, as well as degenerative diseases. Of these, degenerative diseases are the most common. While low back pain (LBP) is one of the most common causes of disability, it is usually not related to diseases of the spine. LBP is often considered non-descript and typically expresses itself as pain and discomfort in the low back. Pathologies of the spine on the other hand, typically express themselves with radiating, neuropathic pain. Diseases which impact the cervical spine can be observed with neuropathic pain radiating from the neck and down the arms to the fingers, whereas diseases of the thoracic and lumbar spine are typically associated with neuropathic pain radiating down the legs towards the toes. Degenerative spine diseases exist in 20-25% of the population (Kalichman et al., 2009a) and increase with age (Issack et al., 2012; Kalichman et al., 2009a).

The pathophysiology of the spine when subject to a degenerative disease may vary but will result in similar symptoms. In all situations, pain and disability are due to an impingement of the nerve root in the spinal column. The types of diseases that affect the spine are either due to a disc herniation, a stenosis, a spondylolisthesis, or a cervical myelopathy.

Disc herniations are the most common form of degenerative disease. The incidence is 5-20 cases per 1000 adults per year, with men having double the incidence of women (Fjeld et al., 2019) and the prevalence is 1-3% (Dydyk et al., 2023). Unlike other degenerative

diseases, disc herniations have a chance of spontaneously resolving, with research reporting up to 67% of cases resulting in resorption of the disc (Zhong et al., 2017). However, recurrent disc herniation at the same level has also been reported to occur in 12.1% of those who receive surgery for a primary discectomy (Geere et al., 2023). A disc herniation causes disease in the spine by the interstitial disc space herniating into the spinal column, causing an impingement of the nerve root.

A stenosis is an impingement of the nerve root in the vertebra, by degeneration of the vertebra. This degeneration can derive from bone on bone rubbing causing bone spurs which then impinge the nerve root. Alternatively, degeneration of the facet joint or the lamina can also impinge the nerve root. Lumbar stenosis is the most common indication for surgery in patients over 65 years of age (Lurie and Tomkins-Lane, 2016). The incidence of lumbar spinal stenosis is between 2.6-4.7%, and the prevalence of this stenosis is between 4-20% for those under the age of 40 and increases to 19.4-47.2% for patients over the age of 60 (Kalichman et al., 2009a), with the lower estimate representing “absolute” stenosis, and the higher estimate representing “relative” stenosis.

A spondylolisthesis is a slippage of one vertebra over another. This slippage of the disc causes one vertebra to impinge the nerve root in the spinal column. Spondylolisthesis is more common in men, and the prevalence of the disease is approximately 10.6% for men and 5.0% for women (Kalichman et al., 2009b), and can range from 6 (Beck and Simpson, 2019) to 8% (Kalichman et al., 2009b) in the general population.

Management of Spine Disease

Conservative management

For patients living with spine disease, a multitude of options are available to manage symptoms. Typically, patients are offered conservative management as the first approach. Conservative management includes over-the-counter medications aimed at relieving pain, exercise, or physiotherapy as per the National Institute for Health and Care Excellence (NICE, 2017). Following physiotherapy and analgesic approaches, spinal injections may also be offered (Lurie and Tomkins-Lane, 2016).

Surgical Indications

Surgery may be offered if conservative management fails and patients have debilitating neuropathic pain (which could lead to disability) (NICE, 2017). It is also important to highlight that accurate diagnosis of spinal disease is vital. LBP is prevalent in 70-85% of the population (Andersson, 1999); however, only approximately 5-10% of patients with LBP actually have specific back disease that originates in the spine itself (Koes et al., 2010). Due to how uncommon specific spinal pathologies are, appropriate steps for managing disease are important in order to avoid unnecessary treatment for the patient. Symptoms which may indicate specific spinal disease include leg pain which is typically worse than the back, numbness or paresthesia, neurogenic claudication limiting walking tolerance, and bilateral leg pain (Bardin and Maher, 2017).

While both conservative management and surgical intervention are potentially appropriate options for patients with degenerative spine disease, other factors should be considered that aren't solely related to the symptomatology of the disease. For example, surgery is

effective for providing rapid pain relief for patients with a lumbar disc herniation. However, these patients also have a chance at spontaneous resolution of disease, and many patients will get better over time without operative intervention (Schoenfeld and Weiner, 2010). Furthermore, surgery is only indicated to be appropriate for patients with severe, life-limiting, and chronic pain which is not responsive to conservative treatment (NICE, 2017).

Surgical process for spine surgery

Surgery encompasses three distinct phases crucial to the patient's care and recovery (Davrieux et al., 2019). The pre-operative phase involves comprehensive assessments, medical evaluations, and preparations, ensuring the patient is optimized for surgery. This stage includes obtaining informed consent, conducting tests (e.g., blood work and/or imaging), and planning anesthesia. The peri-operative phase encompasses the surgery itself, where the surgical team performs the procedure under controlled conditions. Anesthesia management, monitoring vital signs, and ensuring aseptic techniques are pivotal during this phase. Post-operatively, care shifts to recovery and rehabilitation. Monitoring for complications, managing pain, and initiating early mobilization are key priorities. Follow-up care and discharge planning are coordinated to facilitate the patient's transition to home or further care facilities, ensuring continuity of recovery. Each phase is meticulously managed to optimize outcomes and promote patient well-being throughout the surgical journey.

Types of Spine Surgery

There are two approaches that can be used for spine surgery. A decompression alone or a decompression and fusion (Tables 1.1 and 1.2). A decompression alone removes some of

the bony tissue that is impinging the nerve root in the spinal canal. For example, if the facet joint has bone spurs, a facetectomy can be performed to remove some of the bony elements which impinge the nerve root. The removal of this tissue is the decompression itself. In some instances, if there is significant deterioration of the vertebra or there are concerns about the stability of the spine following surgery, a decompression and fusion will be performed.

A decompression and fusion follow the same approach as the decompression alone. Following decompression of the nerve root, screws will be installed into adjacent vertebrae and to the vertebra on which the decompression was performed. This hardware is then connected, "fusing" the vertebrae together. While fusion will reduce range of motion of the spine, it helps protect the spine from surpassing its normal range of motion and reduces the risk that a future surgery may be necessary. In the last decade, fusions have become increasingly common, from 46 to 80 procedures per 100000 persons per year (Goz et al., 2013).

There are benefits and potential issues with electing to perform either a decompression alone or a decompression and fusion and, to date, the literature also remains undecided on which is the best approach. A decompression alone is a faster procedure involving a smaller incision thereby reducing risk of infection. It is also a more economical procedure for healthcare systems to perform than the decompression and fusion. However, in situations where there are concerns about the stability of the spine, a decompression alone may be inadequate, and a future fusion could be necessary for these patients.

A recent systematic review and meta-analysis (Gadjradj et al. 2023) focused on decompression alone vs decompression with fusions for patients with lumbar stenosis and degenerative spondylolisthesis. Results suggested there was no difference in function of the spine following a decompression alone compared to a decompression and fusion at 2-year follow-up (Gadjradj et al., 2023). However, the authors noted that 2-year follow-up may not be adequate to determine long-term outcomes for this comparison. High quality randomized trials have also been performed. A study by Karlsson et al. (2022) compared decompression alone vs decompression and fusion for lumbar spinal stenosis for a population of 211 patients, where 108 had decompression alone. They observed patients who had a decompression and fusion in the event of a spondylolisthesis were subject to an increased rate of a new stenosis 2 years following the procedure (45% vs 29%) (Karlsson et al., 2022). However, they observed no statistical difference in subsequent stenosis in those patients with a lumbar stenosis without a spondylolisthesis, even though a greater proportion of those with a decompression alone had a stenosis (45% without fusion and 35% without) (Karlsson et al., 2022).

Table 1.1: A list of approaches for a decompression surgery.

Procedure
Laminectomy Primarily used for lumbar spinal stenosis, myelopathy, spondylolisthesis or instability (Greenberg, 2016). A laminectomy involves the removal of lamina and spinous process (Abduljabbar et al., 2018). In some cases, an incomplete laminectomy will be performed to preserve the lamina and ligaments, called a laminoplasty (Abduljabbar et al., 2018). Laminectomy alone has been shown to improve symptoms related to spine disease. However, spine instability and kyphosis are likely to reappear following the procedure (Abduljabbar et al., 2018). For patients with spondylolisthesis, it was found that the addition of spine fusion to laminectomy showed a significant improvement in SF-36

(physical component) score at 2 years (Ghogawala et al., 2016). A lower re-operation rate was also evident. An improvement in Oswestry disability index (ODI) was noted for the fusion group as well but was not statistically significant (Ghogawala et al., 2016). Laminectomy alone is recommended only for patients with a stiff cervical spine. Spine stability is particularly impacted for forward bending after a laminectomy and after a higher-level procedure (2 or more) even for standing (Zander et al., 2003).
Facetectomy This procedure is performed when a herniation or stenosis is found in the foramen (Epstein, 2018). A facetectomy involves removing the entirety of the facet joint whereas a foraminotomy only removes enough of the facet joint to alleviate pressure on the spinal nerves being affected (Greenberg, 2016). Due to the potential for instability during a facetectomy, fusion is commonly also needed (Youn et al., 2017). A facetectomy has been shown to improve patient reported outcome measures (ODI and SF-36) within 1 month and has been found to be maintained at a 2-year follow-up (Youn et al., 2017). Patients with a narrowing of the space in the foramen on the nerve root experience back pain and radicular symptoms (Youn et al., 2017). Facetectomy will tend to decrease spinal stability in the presence of axial rotation (Zander et al., 2003).
Discectomy A discectomy is used in order to treat a herniated disc in the spine (Greenberg, 2016). In the US, discectomy is the most common procedure performed on patients with back and leg pain (Weinstein et al., 2006). In the presence of a disc herniation, the herniated material may be asymptomatic or may cause pain when nerve-root irritation is present (Weinstein et al., 2006). Compared to non-treatment, discectomy was shown to marginally improve patient outcomes at 2-years (Weinstein et al., 2006). However, both patient groups will still improve based on patient-reported outcome measures (ODI and SF-36) (Weinstein et al., 2006). This is further validated by another study, where discectomy compared to conservative management was equally effective in regard to quality assisted living years (Selva-Sevilla et al., 2019). Furthermore, discectomy alone was proven to yield improved quality assisted living years compared to a patient receiving discectomy and fusion (Selva-Sevilla et al., 2019).

* Each procedure attempts to reduce impingement of the nerve root through the removal of the associated tissue intruding on the spinal canal.

Table 1.2: A list of fusion procedures that accompany a decompression.

Fusion Approach
Anterior lumbar interbody fusion (ALIF) An anterior approach where the patient is positioned supine on the operating table (Mobbs et al., 2015). This approach is effective as it allows maximization of implant size of the interbody graft. While this preserves muscle tissue on the low back, there is

an increased risk of complication related to visceral and vascular injury (Mobbs et al., 2015).
Posterior lumbar interbody fusion (PLIF) Access to the intervertebral disc is done posteriorly, through the back, with a patient positioned prone on the operating table (Mobbs et al., 2015). Poor indications associated with PLIF include epidural scarring and arachnoiditis (Mobbs et al., 2015). Advantages include easy visualization of nerve roots and adequate interbody height restoration (Mobbs et al., 2015).
Transforaminal lumbar interbody fusion (TLIF) A posterior approach in which there is there is direct access to the intervertebral foraminal space (distinguishing it from the PLIF) (Mobbs et al., 2015). The TLIF approach preserves more ligamentous structures compares to the PLIF (Mobbs et al., 2015).
Lateral Lumbar Interbody Fusion (LLIF) A newer technique that allows access to the lower thoracis and upper lumbar vertebrae (Mobbs et al., 2015). The disc space is accessed through the transpsoas corridor, with the patient in a lateral position. This approach is not applicable for severe spinal stenosis or spondylolisthesis (Mobbs et al., 2015). Advantages include the facilitation of a minimally invasive approach and rapid-mobilization post-op. However, there is an increased risk of bowel and vascular injury (Mobbs et al., 2015).
Anterior Cervical Discectomy and fusion (ACDF) The most commonly used/preferred approach for cervical fusions in which the surgeon's access is through the front of the neck primarily between c3-7 (Greenberg, 2016). For other levels, a posterior approach is used (Greenberg, 2016). This is the only approach which can deal with a centrally herniated disc. However, more immobility may result from this approach compared to a posterior one (Greenberg, 2016).

Advances in Surgical Technique

While in-hospital recovery from surgery for degenerative pathologies of the spine can take several days, surgical technique for minimally invasive surgery (MIS) has been advancing over the past several years (Banczerowski et al., 2015, Patel et al., 2020), Goldberg et al., 2022) to improve the safety and recovery of spinal surgical procedures. While MIS has been adopted by general surgeons for decades, spine surgery has only begun to utilize this approach in recent years. This is due, in part, to the difficulty associated with free-hand pedicle screw placement, meaning larger incisions are necessary in order to expose both the screw entry point and the surrounding anatomy in

order to observe the optimal screw trajectory while also avoiding neurovascular structures (Goldberg et al., 2022).

Current MIS approaches for spine surgery include both tubular and endoscopic approaches. The tubular approach for spine surgery was described in 1999 by Foley et al. (1999). In this approach, an incision of approximately 15mm is made and a tube which spreads muscle and ligament tissue is inserted. The surgery is performed in its entirety within this tube. Compared to open approaches, this tubular approach spreads muscle instead of dissecting bone and cutting more tissue (Foley et al., 1999). This facilitates smaller incisions, less blood loss during surgery, and reduces the risk of infection from the surgical site and length of stay (LoS) (Pokorny et al., 2022). There are also potential cost savings for healthcare systems associated with MIS approaches when compared to open spine surgery, with most cost saving being associated with reduced LoS and less complications observed with MIS (Allen and Garfin, 2010; and Pokorny et al., 2022).

Another common MIS approach is endoscopy (Patel et al., 2020; and Goldberg et al., 2022). An endoscopic approach uses an endoscope which has a camera port at the end of the scope as well as a light source, an irrigation channel, and a working channel through which the operation can be completed (Hasan and Hofstetter, 2019; and Goldberg et al., 2022). Endoscopy is particularly beneficial due to its wide field of view of the spinal anatomy; visualization is improved due to a reduction in blood loss resulting from a smaller incision and constant irrigation from the endoscope (Goldberg et al., 2022). Endoscopic approaches have also been shown to be more cost effective than open approaches, even though the cost of the procedure itself was observed to be more than

open spine surgery (Goldberg et al., 2022; and Golan et al., 2023). Like the tubular approach, most cost savings were associated with reduced LoS (Golan et al., 2023).

Compared to open approaches, tubular and endoscopic approaches have significant advantages. According to Goldberg et al (2022), endoscopic approaches are the most expensive to perform and have the steepest learning curve. However, they also allow for awake spine surgery and offer the smallest incision (Goldberg et al., 2022). Both tubular and endoscopic approaches have shown reduced LoS, reduced narcotic use following surgery compared to open approaches, and have lower rates of postoperative infection (Goldberg et al., 2022).

As mentioned, endoscopic approaches allow the opportunity to perform awake spine surgery using local anesthetic. A systematic review by Rajjoub et al. (2023) observed that awake spine surgery cases had a reduced mean difference in LoS by -0.40 days, and that the complication rate was significantly higher for patients in the general anesthesia group (Rajjoub et al., 2023). They also observed that, post-operatively, patients who received local anesthetic had significantly lower rates of nausea/vomiting (Relative risk=0.60) as well as urinary retention (Relative risk=0.61) (Rajjoub et al., 2023). While this review points towards the benefits of awake spinal surgery, there has been poor uptake in its use (Basil and Wang, 2019; and De Biase et al., 2023). A study by De Biase et al. (2023) observed that most surgeons did not believe that local anesthesia was more beneficial for spine surgery compared to general anesthesia but that findings from more high-quality randomized studies would likely improve surgeon perspective on the adoption of local spinal anesthesia (De Biase et al., 2023).

Robot assisted surgery could become a future tool in spine surgery to help ensure accuracy of the placement of pedicle screws during fusion procedures (Joseph et al., 2017). Similar to MIS approaches, the uptake of robot assisted spine surgery has been delayed compared to general surgery (Goldberg et al., 2022). There are three types of surgical robots (passive, semi-active and active) each with varying degrees of autonomy. (McDonnell et al., 2020). Passive surgical robots act more as support during an operation as opposed to more active robots which autonomously perform a task without a surgeon (McDonnell et al., 2020). The main advantage of robot-assisted surgery is in the wide range of view provided by the robot as well as the improved precision associated with installing pedicle screws for fusion procedures when compared to a free-hand approach (Jospeh et al., 2017). Furthermore, the use of robot-assisted surgery has been shown to reduce radiation exposure by up to 30% while using fluoroscopy for navigation. An estimated 10 surgical cases are needed for a trainee to develop skillful control of the robot to achieve this reduction in exposure time (Kim et al., 2017).

While improved precision for pedicle screws is advantageous for the patient regarding the success of their surgery, there are some growing pains associated with the uptake of robot-assisted surgery. Primarily, there are significant barriers to both the cost and the learning curve for the robot. The average cost of a spine-assisted robot ranges from $550,000 to $1.1 million plus an average of $1500 per surgery for disposable equipment (Fiani et al., 2020; and Goldberg at el., 2022). A systematic review revealed instances where the robot failed by either failing to register the software and obtain fluoroscopic images or via inaccurate screw placement due to soft-tissue pressure on the guiding arm

(Joseph et al., 2017). This review suggested that misplacement of screws peaks between 5-25 cases but steadily declines after that point (Joseph et al., 2017).

In summary, while spine surgery has been slow to adopt many of the advances that other surgical fields have been performing for decades, the utilization of MIS techniques, spinal anesthetic for awake surgery, and robot-assisted surgery point toward a future of outpatient spine surgery.

Issues Associated with Spine Surgery and Recovery:

Spine surgery is often associated with significant morbidity and disability following the procedure. In particular, recovery after spine surgery often requires several days in hospital plus continuing physiotherapy and medication following the procedure.

The in-hospital stay for patients is particularly problematic. Research has shown that each day a patient stays at a hospital (as an inpatient) increases the risk of adverse events to that patient by 5% daily, including events such as delirium and infection (Mathew et al., 2018).

Length of stay is also problematic for healthcare systems. In many surgical procedures, the cost of the inpatient stay is frequently the most expensive component of offering a patient surgery. On top of large costs for healthcare systems associated with long LoS, patients who take up hospital beds prevent the admission of new patients who are also in need of surgery, contributing to long surgical waitlists. Furthermore, there are qualitative benefits to more efficient discharge of patients as well, with many patients reporting higher satisfaction with their surgery when they are discharged more quickly (Peres-da-Silva et al., 2017).

Currently, LoS is variable for patients who undergo surgery for degenerative pathologies of the spine. With the increase in utilization of minimally invasive techniques and surgery for single levels of disease (e.g., operations on only one vertebra), some spine procedures can be performed as an outpatient procedure. The average LoS for spine surgery is 4 days (Goz et al., 2013) but can range from hours (Soffin et al., 2019) to over two weeks, particularly in an elderly population (Li et al., 2021).

Enhanced Recovery After Surgery

Development (from Fast track to ERAS)

In the 1990s, Henrik Kehlet, a colorectal surgeon, popularized a multimodal management approach focussed on improvements to the pre-, peri-, and post-operative phases of a patients care known as Fast-Track Surgery. Kehlet and Wilmore provide a succinct description of fast track surgery and a critical overview of its use and evaluation in practice, in their paper, "Evidence-based surgical care and the evolution of fast-track surgery" (Kehlet and Wilmore, 2008). Below is an excerpt from their paper that succinctly describes the development and evolution of fast-track surgery from 1966 until 2007:

> *"This multimodal approach, referred to as "fast-track surgery," incorporates not only surgeons but also anesthesiologists, nurses, and physical therapists (Kehlet and Wilmore, 2002; Kehlet and Dahl, 2003) as active participants of the care team. Fast-track surgery focuses on enhancing recovery and reducing morbidity by implementing evidence in the fields of anesthesia, analgesia, reduction of surgical stress, fluid management, minimal invasive surgery, nutrition, and ambulation." ... "Initial results of multimodal programs to enhance recovery have generally been nonrandomized, single-center observations from investigators developing the initial concept. More recently, information from randomized trials and systematic reviews has become available, especially in FastTrack colorectal programs (Wind et al., 2006; Khoo et al., 2007; Kehlet, 2008). In the available series, which should serve primarily to stimulate further research, postoperative organ dysfunctions seem to be significantly attenuated, and as a consequence hospital stay has*

been reduced to levels unreported in the past. Importantly, these observations suggest that the risk of "medical" complications is reduced (Wind et al., 2006; Khoo et al., 2007; Kehlet, 2008, Basse et al., 2004). Reports also suggest that the costs are decreased100 although there has been some skepticism of this information because of the potential for transfer of costs to another post discharge environment. However, this is not supported by comparative data from colonic surgery (Jakobsen et al., 2006). Furthermore, costs for hospital stay in the later postoperative period are less when compared with the first days, and the opportunity costs of having additional beds available with short-term surgical stay is rarely included in these evaluations. Therefore, large, more sophisticated economic analyses are needed within all aspects of fast-track surgery. So far, the data suggest that the amount of nursing care per patient course is reduced by a fast-track program."

This approach incorporated elements such as reduced fasting and oral nutrition (in the pre-operative phase), a reduction of drains (in the peri-operative phase) and non-opioid pain management (in the post-operative phase). In Kehlet's original work for colorectal surgery, the "fast-track" approach was tested on small cohorts of surgical patients where they found a reduction in LoS from five to two days (Khelet & Mogenson, 1999). Success of use of fast-track approach can attenuate the physiologic stress response, which contributes to a reduction in hospital stay for patients who undergo these programs (Kehlet and Wilmore, 2008). Furthermore, hospital systems stand to benefit from the rapid turnover of hospital beds during a fast-track approach to care, both monetarily and increasing opportunity for bed space (Kehlet and Wilmore, 2008).

The fast-track approach has since evolved into what is currently referred to as the Enhanced Recovery After Surgery (ERAS) intervention in order to emphasize surgical quality as opposed to speed of recovery (Ljungqvist et al., 2017). In 2010, the ERAS Society was established and has since created various consensus guidelines for different types of surgeries, such as colorectal surgery, bariatric surgery, hip and knee arthroplasty

and caesarean surgery (ERAS Society, 2024). Currently, there are no formal guidelines for spine ERAS.

Following the success of ERAS in the early 2000's, the ERAS Society was formed in 2005 and released the first formal ERAS guidelines for colorectal surgery at the time (Fearon et al., 2005). Since then, the ERAS society has 34 various guidelines and recommendations across 23 different specialties (ERAS Society, 2024). Furthermore, the ERAS society currently offers a Centre of Excellence accreditation for hospitals which qualifies them as a teaching centre for the implementation of ERAS or have made substantial contributions to the development of ERAS (ERAS Society, 2024). To date, there are 35 centers globally, with two of them in Canada, being McGill University Health Center, and ERAS Alberta (ERAS Society, 2024).

ERAS Strategies

ERAS interventions focus on including a variety of strategies (that may or could work together) to reduce the stress response related to surgery (Ljungqvist et al., 2017). For example, reducing stress can be done by maintaining homeostasis, which allows the patient to avoid catabolism and prevents the loss of muscle strength (Ljungqvist 2012). Thus, strategies could include ensuring optimal nutritional support for the patient through carbohydrate loading prior to surgery. While the strategies included within each ERAS intervention should be tailored to the type of surgery that is offered, there is also a lot of overlap in the strategies that are used (e.g., early mobilization is almost always included in any ERAS intervention).

Many high quality randomized controlled trials (RCTs) and systematic reviews have shown the positive benefits of implementing ERAS interventions, particularly in fields in which formal ERAS guidelines are present. For example, in bariatric surgery, a systematic review and meta-analysis by Parisi et al. (2020) found a significant decrease in LoS of -0.51 days (CI: -0.92, -0.10, p=0.01) over five randomized trials. Another systematic review and meta-analysis by Zhang et al. (2020) observed a significant decrease in LoS of -1.12 days (CI: -1.80, -0.45, p=0.001) following an ERAS intervention for radical cystectomy across seven RCTs.

In addition to LoS and re-admission, studies also examined other outcomes, such as, cost, functional ability and pain scores. While cost analyses are frequently included in analyzing the success of an ERAS program, with a majority of ERAS programs observing a cost reduction with ERAS (Ljungqvist et al., 2017), few studies in spine have reported cost. For all spinal procedures, Heathcote et al. (2019) reported that spine ERAS observed an average per patient cost reduction of $2865.00 USD. Other outcomes, such as patient reported outcome measures (PROMs) are also infrequently reported in spine ERAS, but could also be beneficial for determining if ERAS is beneficial, or at least not detrimental to the patient. For example, the Oswestry Disability Index (ODI), is a common diagnostic tool used in spine surgery to assess how severely the patient's spinal pathology contributes to their disability and day to day life. One study by Garg et al. (2020) observed that patients in the ERAS group had an average ODI which was 3.80 points less than the standard of care group. For other PROMs, measuring pain on a scale from 0-10 or 0-100 is also common, but less frequently reported in the ERAS literature. For

example, a study by Cui et al. (2022) observed statistically similar reporting in post-op visual analogue scale (VAS) scores, of 1.40 in the ERAS group, and 1.58 in the standard of care group. Similarly, Garg et al. (2020) also observed a VAS of 49.8 in the pre-ERAS group, and a score of 44 in the post-ERAS group. Regardless of surgery type (eg. Bariatric, spine and radical cystectomy), there are many other secondary outcomes that are less frequently reported, such as complications rates (42.86% of the time, Zhang et al., 2020), or pain scores (60.00% of the time, Parisi et al., 2020). As such, it is challenging to know much about the effect of ERAS on these other outcomes.

Based on the above literature, several gaps are clear including a general lack of reliable information the effectiveness of ERAS for spine surgery, and which strategies to include during each phase, let alone how to implement spinal ERAS. Additionally, there is little information on adherence to ERAS protocols in spine.

Spine ERAS Strategies

While no formal guideline or logic model exists for spine ERAS, a consensus statement was developed in 2021 by Debono et al. which assesses multiple potential strategies which may be included in a spine ERAS protocol (Table 1.3). We have created a table in appendix 1.1 detailing a list of potential ERAS strategies and how they are meant to work, and which discharge criteria they are thought to impact.

After we developed this table, a consensus statement was developed for the ERAS® Society by Debono et al. (2021a). While this isn't a formal guideline, it does summarize a list of recommended ERAS strategies for spine surgery (see Table 1.3). This list includes many of the strategies listed in appendix 1.1 and thus will serve as the most up-to-date

synthesis of the individual effectiveness of each of the strategies. To develop this list, the Grading of Recommendations, Assessment, Development, and Evaluations (GRADE) system was used to assess the evidence quality and recommendations for each ERAS topic (Debono et al., 2021a). Initial recommendations were formed based on whether the evidence quality was categorized as high, moderate, low, or very low. However, the strength of these recommendations in the final list depended on an analysis of the potential positive and negative effects of the recommendation. For example, a strong recommendation for an ERAS element was made, in some cases, even when the evidence quality was low, provided the potential for harm was minimal (Debono et al., 2021a). Disagreements regarding evidence quality and recommendation grading were resolved through consensus discussions or, if necessary, by employing a Delphi process. The team exercised caution in issuing strong recommendations in areas where specific procedural evidence was lacking, aiming to prevent the establishment of new ERAS practices unsupported by evidence.

Table 1.3: A re-ordering and synthesis of recommended ERAS strategies for spine surgery developed by Debono et al (2021a) for the ERAS Society.

Strategy Topic	**Recommendation**	**Recommendation grade**	**Evidence level**
Preoperative phase			
1. Preoperative fasting and carbohydrate loading	1. Clear fluid should be permitted up to 2 hours and solid foods up to 6 hours before the induction of general anesthesia	Strong	High
2. Preoperative cessation of smoking	2. A combined smoking cessation therapy at a minimum of 4 weeks before surgery is recommended	Strong	Moderate

3. Preoperative cessation of alcohol	3. Alcohol cessation programs 4−8 weeks before surgery can reduce postoperative complications.	Strong	Moderate
4. Preanesthetic medication	4. The routine preoperative administration of acetaminophen, NSAIDs, and gabapentinoids as part of a multimodal opioid sparing analgesia strategy is recommended	Strong	Moderate
	5. The routine administration of sedatives to reduce anxiety preoperatively is not recommended	Strong	Low
5. Preoperative education and counselling	6. Preoperative patient education is recommended	Strong	Low
6. Anemia management	7. Preoperative anemia should be assessed and corrected prior to lumbar fusion.	Strong	Low
7. Preoperative nutritional supplementation	8. Patients undergoing lumbar fusion should undergo a preoperative nutritional assessment.	Strong	Low
	9. Preoperative nutritional interventions should be offered to patients identified as malnourished	Strong	Low
	10. Evidence is currently insufficient to make a recommendation on routine use of oral carbohydrate load for lumbar spine fusion.	-	-
8. Prehabilitation	11. Evidence is currently insufficient to make a recommendation on prehabilitation as an essential intervention for all patients	-	-
Peri-operative phase			
9. Preventing intraoperative hypothermia	12. Normothermia should be maintained peri- and postoperatively through pre-	Strong	High

	warming and the active warming of patients intraoperatively		
10. Local anesthetic techniques	13. Use of intrathecal analgesia with long-acting local anesthetics should be used to improve postoperative pain management.	Strong	High
	14. Use of epidural analgesia with long-acting local anesthetics should be used to improve postoperative pain management.	Strong	High
	15. Use of locoregional blocks with long-acting local anesthetics should be used to improve postoperative pain management.	Weak	High
	16. Use of wound infiltration with long-acting local anesthetics should be used to improve postoperative pain management.	Strong	High
11. Antimicrobial prophylaxis and skin preparation A care bundle should be implemented, including administration of a broad-spectrum antibiotic covering S. aureus, and skin preparation using either alcohol-based iodine or chlorohexidine solution.	17. Administration of a broad-spectrum antibiotic covering S. aureus (with possibility of repeating doses during longer surgeries)	Strong	High
	18. Skin preparation using use of either alcohol-based iodine or chlorohexidine solution	Strong	High
	19. Antiseptic dressing the night before surgery	Moderate	Low

12. Standard anesthetic protocol	20. Modern general anesthesia, including the use of neuromuscular blockade and neuraxial techniques should be used as part of multimodal anesthetic strategies follow local policy and availability.	Strong	Moderate
13. Urinary drainage	21. The routine use of urinary catheters is not recommended for short-segment elective lumbar spinal fusions with or without concomitant decompression. When used, they should be removed within hours of surgery with close monitoring.	Weak	Moderate
14. Perioperative fluid management	22. Intravenous fluids should maintain near-euvolemic status.	Strong	Moderate
	23. Goal directed fluid management is not needed for 1-2 level lumbar fusion but should be considered if significant patient co-morbidities exist.	Strong	Low
15. Surgical techniques	24. Surgical technique should be decided on a case-by-case basis factoring the goals of surgery, training and experience of the surgeon, and the availability of technology at the local institution.	Strong	Low
16. Early postoperative oral nutrition	25. An early return to normal diet is recommended and should be promoted.	Strong	Low
Post-operative phase			
17. Postoperative nausea and vomiting	26. Risk assessment for PONV, routinely use of multimodal PONV prophylaxis based on assessment, and PONV	Strong	High

	rescue with different class of anti-emetic are recommended		
18. Postoperative analgesia	27. The routine use of multimodal analgesic regimens to improve pain control and reduce opioid consumption is recommended.	Strong	Moderate
19. Postoperative management of drains	28. Routine wound drainage is not recommended for short-segment lumbar fusion surgery.	Strong	Moderate
20. Prophylaxis against thromboembolism	29. Early ambulation and the use of mechano-prophylaxis should be encouraged in all patients after spinal surgery.	Strong	Moderate
	30. Pharmaceutical antithrombotic prophylaxis should be reserved for specific risk groups, while no recommendation can be made with regard to its standardized use.	Strong	Low
21. Early mobilization and in-hospital physical therapy	31.Early mobilization and early physical therapy are recommended.	Strong	Low

The consensus statement reviewed a total of 31 specific recommendations across 21 strategy topics. Overall, the consensus statement recommended that spine surgery ERAS interventions should include 26 specific recommendations, exclude three recommendations, and was unable to comment on two recommendations. A discussion of each of these can be found in the following paragraphs.

The twenty-six recommendations for inclusion crossed all three surgical phases (9 pre-operative, 12 peri-operative, and 5 post-operative). The strength of the evidence

supporting these strategies was variable. Nine of the strategies were supported by high level of evidence, nine were supported by moderate level of evidence, and 11 by low level evidence. Nevertheless, as many of the strategies were believed to offer benefit to patients without the introduction of potential harm, the vast majority of the strategies were *strongly* recommended for inclusion.

Three recommendations for exclusion were noted (two in the peri-operative phase and one in the post-operative phase). These include the use of locoregional blocks with long-acting local anesthetic, as well as the use of antiseptic dressing the night before surgery, and the use of routine urinary catheters for short-segment elective lumbar spinal fusion. Finally, the authors of the consensus statement were unable to provide any recommendation on two strategies related to the pre-operative phase as there was not enough evidence available to make any judgement. These being the use of a prehabilitation program, as well as the routine use of oral carbohydrate loading for lumbar spine fusion.

At the time of writing this introductory literature review, the most up-to date evidence regarding the effectiveness of spine ERAS interventions suggested that spine ERAS interventions may reduce LoS (Elsarrag et al., 2019; Dietz et al., 2019; Tong et al., 2020, and Pennington et al., 2020). However, this evidence was primarily generated from reviews that included many different types of patient pathologies (e.g., deformity, tumor, degenerative disease) making it difficult to assess the specific impact of the interventions on patients with degenerative spine disease undergoing elective surgery (Elsarrag et al., 2019; Dietz et al., 2019; Tong et al., 2020, and Pennington et al., 2020). In addition, these reviews were largely narrative (Elsarrag et al., 2019; Dietz et al., 2019; and Tong et al.,

2020) and did not perform risk of bias assessments (Elsarrag et al., 2019; and Pennington et al., 2020), adhere to the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines (Elsarrag et al., 2019), used limited search strategies (Elsarrag et al., 2019; Dietz et al., 2019; and Tong et al., 2020), did not synthesize data in a meta-analysis (Elsarrag et al., 2019; Dietz et al., 2019; and Tong et al., 2020), or use the GRADE criteria to assess the certainty of the evidence. Appendix 1.2 has a brief overview of these reviews.

ERAS Planning at the Queen Elizabeth II:

In 2019, the Neurosurgery Division at the QEII Hospital began a working group to determine if and how they could develop an ERAS Spine program and address some of the literature gaps noted above. Below I describe the QEII and the process for developing the working group.

The QEII health Sciences Centre is located in Halifax, Nova Scotia and includes two sites, being the older Victoria General Hospital, and the Halifax Infirmary. The Halifax Infirmary provides services for patients with spinal disease in both Nova Scotia and Prince Edward Island, with the Infirmary being the only centre which offers spine surgery in both provinces. At the QEII hospital, there are four spine surgeons, two neurosurgeons and two orthopaedic surgeons. Both clinics are found on the fourth floor of the Halifax Infirmary, and the operating rooms are located on the fifth floor, of which there are 16. Patients who are scheduled to see a spine surgeon can expect a wait of approximately 12-18 months to see a specialist, and if offered surgery, another 8-12 months to receive the procedure. An estimated 300 elective spine surgeries are offered each year, with most of these being degenerative cases. While the procedures offered by both neurosurgeons and

orthopaedic surgeons include both decompressions alone and decompression and fusions for patients with degenerative spine disease, the approach may differ. For example, both neurosurgeons are trained in minimally invasive techniques, whereas the orthopaedic surgeons use a microscope assisted approach. As of August 2022, Dr. Sean Christie performed the first robot-assisted spine surgery in Canada and is currently using it in his practice. The other spine surgeons are also trained/training on the robot, and incoming and current residents receiving spine surgery training also are taught to use it.

In terms of ERAS, no enhanced recovery protocol is currently implemented for elective spine procedures. The current process for work-up and post-surgery recovery for patients seeing either a neurosurgeon or an orthopaedic surgeon is the same and can be described as follows: Patients attend an initial consult with the surgeon, if offered surgery, they are then given a 30-page booklet by the surgeon who also obtains informed consent for the surgical procedure. The administrative assistant calls the patient with a surgery date and advises them to fast before their surgery. Following spine surgery, patients can expect a brief stay in the post-anesthesia care unit (PACU), as they come out of general anesthetic. Following the PACU, day surgery patients are discharged home, and patients who will recover in hospital will be moved to the 7th floor of the infirmary. The 7th floor (unit 7.3) has a specialized spine unit, where all spine surgery patients who are not outpatient will go. In the event of overflow, these patients will occasionally recover in the adjacent orthopaedic unit, 7.2, or on the 8th floor on unit 8.3. Unit 7.3 has a team of nurses, nurse practitioners, a dietician, spine surgeons and residents receiving training in spine surgery who will attend patients and do rounds. Other allied health which sees spine patients but are not exclusively working for the spine unit include physiotherapy (PT) and

occupational therapy (OT). Residents and/or the surgeons round patients starting at 6am. Following rounds, the resident and the surgeon will determine if the patient will be discharged home.

In 2019, discussions amongst the neurosurgery team identified a growing body of research regarding ERAS in other surgical fields and considered its applicability for elective spine surgery. The director of research (Dr. Sean Christie) invited ERAS expert Dr. Thomas Wainwright to Halifax, Nova Scotia, for consultation regarding how to develop an ERAS program at the QEII. Initial discussions with Dr. Wainwright suggested a series of research studies that should be conducted, which formed the basis of this thesis. To this end, this thesis sought to determine the efficacy of ERAS interventions for spine surgery in the literature, perform an audit of what factors prevent discharge at our facility in Halifax, Nova Scotia in order to identify what keeps our patients in hospital, and lastly, we worked with patients with lived experience of surgery to identify ways we may be able to improve our educational program to benefit patients and better manage their expectations. In order to accomplish these goals, several studies were designed to answer particular questions related to the development of the ERAS intervention for the QEII Hospital.

Thesis Formatting:

The chapters in this manuscript-based thesis are all considered their own independent work and will be submitted individually for publication. Due to this, some chapters will have repeating information in the introductions.

Chapters 2-6 will cover topics on stakeholder engagement, the efficacy of spine ERAS, analyzing what factors prevent discharge following spine surgery, and patient educational content and strategies.

The first three chapters (Chapters 2-4) aimed to:

- assess stakeholder opinion on the feasibility and ability to implement an ERAS intervention by conducting an engagement study to gain stakeholder input (Chapter 2).
- examine the efficacy of existing ERAS programs reported in the literature using a systematic review and meta-analysis (Chapter 3).
- fine tune and prioritize strategies for inclusion in the ERAS intervention by conducting a prospective clinical audit and descriptive cohort study to understand the reasons for prolonged hospital stays following spine surgery by conducting a prospective clinical audit and descriptive cohort study (Chapter 4).

The final two chapters (Chapters 5-6) take a more in-depth look at the patient education component of ERAS interventions for spine surgery. Specifically, they explored education content and delivery mechanisms for this component of an ERAS intervention. These studies aimed to:

- discuss with patients how they engage with educational material and how they would want education to be delivered to them by conducting a patient engagement study (Chapter 5).

- determine how education was delivered to patients undergoing elective spine surgery as part of an ERAS intervention and what content was included in education materials through a systematic review of the literature (Chapter 6).

Chapter 2 : Engaging Stakeholders in the Development of an Enhanced Recovery after Surgery Intervention for Spine Surgery

Ryan Greene[1, 2], Amanda Hall[3], Holly Etchegary[2], Thomas Wainwright[4], and Sean Christie[1]

1. Department of Surgery (Neurosurgery), Dalhousie University, Halifax, NS

2. Faculty of Medicine, Memorial University of Newfoundland, St. John's, NL

3. Primary Health Research Unit, Memorial University of Newfoundland, St. John's, NL

4. Department of Orthopaedics, Bournemouth University, Bournemouth, UK

Co-authorship Statement

As the primary author, I co-designed the study, recorded the data, analyzed it, and drafted the manuscript. Dr. Hall contributed to the data analysis, and review of the manuscript. Dr. Etchegary aided with the data analysis, and also reviewed the manuscript. Dr. Wainwright contributed to the study design, and data acquisition. Dr. Christie assisted with the study design.

Introduction

In recent years, calls for implementing ERAS interventions for spine surgery have been noted, due to the particular benefit they may offer for patients with spine disease (Wainwright et al., 2016). Currently however, there is no standard ERAS intervention developed for spine surgery. ERAS is a complex intervention as defined by the Medical Research Council: it includes multiple components targeting different outcomes, involving multiple health professionals, delivered across three different surgical phases.

The Medical Research Council recommends that intervention development should include early and meaningful engagement with stakeholders to enable sensitivity to contextual factors that influence the impact of interventions (Skivington et al., 2021). By involving a diverse range of stakeholders early and consistently throughout the process of intervention development, interventions can be better tailored to meet the real-world needs and contexts of those they are meant to benefit. This engagement can foster a deeper understanding of the challenges and opportunities surrounding the intervention, promote buy-in and support from key stakeholders, and enhance the likelihood of successful implementation and sustainability of the intervention (Skivington et al., 2021). For example, it has been established in the literature that ERAS interventions are difficult to implement, and the introduction of an ERAS intervention does not, in itself, ensure adherence (or sustainability of the intervention) (Maessen et al., 2007). In order to help facilitate uptake of ERAS interventions, engagement of all members of the multidisciplinary team to assess enablers and barriers to implementation has been recommended (Pearsall and McLeod, 2018). Stakeholders bring invaluable expertise, resources, and perspectives that may enrich the intervention's design, implementation

strategies and evaluation methods, thereby maximizing its potential to achieve meaningful health outcomes and catalyze broader systemic changes in healthcare delivery and policy (Brett et al., 2014; Domecq et al., 2014; Esmail et al., 2015; Forsythe et al., 2018; Forsythe et al., 2019; Maurer et al., 2022; Shippee et al., 2015; and Skivington et al., 2021).

The development of a spine surgery ERAS intervention involves several key stakeholders crucial to its success, representing all three phases of the surgical process (pre-, peri-, and post-operative). These include spine surgeons who provide expertise in surgical techniques and patient care protocols, anesthesiologists who manage peri-operative pain and anesthesia strategies, nurses who implement ERAS strategies such as providing patient education and provide inpatient care, hospital administrators who allocate resources and support implementation efforts, physical therapists who contribute to postoperative rehabilitation plans, and patients and caregivers/support persons who play a pivotal role in adhering to pre- and post-operative guidelines. Additionally, researchers and quality improvement specialists may be involved in monitoring outcomes and refining ERAS strategies based on data-driven insights.

Following the guidance of the Medical Research Council, we engaged with stakeholders to evaluate potential strategies for inclusion in the spine ERAS intervention being developed for the QEII hospital. In this paper, we describe this process to show how we developed an ERAS intervention specific to spinal surgery for our site.

In this paper, we describe how we engage with the stakeholder group of healthcare providers and administrative staff members, in a subsequent paper, we describe our separate engagement with patients.

Methods

Protocol Development

The protocol can be found in appendix 2.1.

Design

Stakeholder engagement via discussion groups was used to develop a comprehensive list of ERAS strategies and evaluate their suitability for inclusion in an ERAS intervention for scheduled spine surgery at the QEII Hospital in Nova Scotia, Canada. Discussion groups are similar to qualitative focus groups; as a method of engagement, their purpose is to inform intervention design rather than answer a specific research question (Doria et al., 2018). As this was a stakeholder engagement activity, ethics review was not required (Doria et al., 2018). Since there are no formal reporting guidelines for stakeholder engagement studies, where possible, we have structured our reporting following the headings for reporting for qualitative studies outlined in the Standards for reporting qualitative research (SRQR) reporting guidelines (O'Brien et al., 2014).

Discussion group preparation

Forming the groups

Team members SDC (spine surgeon) who works at the QEII hospital used his professional network to identify relevant stakeholders for the discussion groups from

September to October of 2019. Both SDC and RG (graduate researcher) extended invitations to the identified stakeholder to attend one of three discussion groups about potential ERAS strategies. All relevant hospital staff working in pre-, peri-, and post-operative surgical phases were invited to participate (n=15). This included spine surgeons (both neurosurgeons and orthopaedic surgeons), anesthesiologists, residents, a nurse practitioner, clinic nurses, inpatient floor nurses and the administrative director. They were invited to participate in the stakeholder engagement session individually, either in person or via email. SDC spoke with surgeons personally and some nursing staff, while RG emailed anesthesiologists identified by SDC, and spoke with or emailed the remaining surgeons, nurses and researchers also identified by SDC. After initial contact, the group was emailed as a whole to facilitate future correspondence. Interested stakeholders were provided a discussion group time depending on which discussion group (pre-, peri-, or post-operative) was most relevant to their professional role.

Developing a preliminary list of strategies

To begin developing a list of potential strategies, RG completed a basic search using PubMed (related search terms for ERAS, spine and surgery), and the ERAS Society website (https://erassociety.org/) for any existing guidelines or papers about ERAS interventions for any surgery. Any study that described an ERAS intervention for any of the three surgical phases (pre-, peri- or post-operative) was included in our review. A standardised data extraction sheet was used to compile data related to study characteristics, intervention strategies, and outcomes assessed. All intervention strategies

that were described in any of the included studies were summarised within their respective surgical phase: pre-, peri- or post-operative.

Context

The stakeholder engagement discussion groups were conducted in person at one hospital, the QEII Hospital in Halifax, Nova Scotia, Canada.

Data Collection

Pre-discussion groups: Two weeks before each discussion group, participants were sent a 2-page summary outlining what an ERAS intervention is, what is known about their general effectiveness from recent systematic reviews, and a comprehensive list of the strategies included in ERAS interventions across multiple surgical fields. Strategies were grouped according to each surgical phase (pre-, peri-, or post-operative). Each participant was asked to review the document, add any additional strategies they thought should be included, and consider which strategies they felt would be most appropriate for our facility. This correspondence was performed mainly via email. In two cases, this communication occurred via one-on-one conversations in-person or on the telephone. Any feedback provided at this stage was used to guide talking points for the discussion group meetings, and to add potential strategies that the stakeholders also thought would be important for a local spine ERAS intervention. No demographic or clinical characteristics were collected from the stakeholders.

Discussion group meetings: Three one-hour discussion groups were held in October 2019. In brief, we had an open-ended conversation for each of the strategies about their

usefulness and any issues around implementation (there was no formal question guide). Our discussion group which was facilitated by three research team members (SDC, RG, TW) with relevant experience in the content area and in qualitative research. During these discussion groups, each of the potential strategies identified for that surgical phase was discussed. The discussion revolved around how the strategy contributed to improving patient outcomes, if it was feasible to implement locally, and what barriers could prevent implementation. We aimed to reach consensus about whether or not the potential strategy should be used as part of an ERAS intervention at our site. After each strategy was discussed for possible inclusion or exclusion, we also discussed potential barriers or enablers that might hinder or facilitate implementation of the strategy. The discussion groups were not audio-recorded. Rather, all opinions were captured for data collection purposes using detailed field notes. At the end of each discussion group, key points discussed during the meeting were reiterated to ensure that each team member was in agreement with what was discussed and had a chance to provide additional feedback. Following the discussion groups, the summarized version of included strategies for the spine ERAS program was disseminated via email to the stakeholders.

Development of Key Recommendations

A summary of the discussion and decisions made were documented and used to develop a list of recommendations for how to implement ERAS at our site. Each component (e.g., patient education, fasting, early mobilization, etc.) of the three phases (pre-, peri-, and post) of the ERAS intervention was discussed during the stakeholder engagement sessions. Each group discussion focused on a specific phase of ERAS (pre-, peri-, and

post-operative). As per Doria et al. (2018), this type of discussion group format does not require a formal data analysis. However, in order to ensure consistency across the three discussion groups, all components of each ERAS phase were considered by the group to determine if they were acceptable to the stakeholder group, practical to implement, potentially effective, and affordable within our units' financial constraints. These criteria were used to identify which ERAS strategies would be included in our ERAS intervention. After each strategy was reviewed and discussed, the group was asked to indicate whether the strategy should be included and encouraged to voice any objections or questions they may have had about the strategy. If there were no objections, the strategy was included. Each strategy for each surgical phase had to be agreed upon by all team members attending the ERAS session to be included in our ERAS intervention.

Results

Participants:

All fifteen stakeholders provided input via email and/or attended stakeholder engagement sessions. All three groups included a mix of health professionals; participants attended the session(s) most relevant to their professional role. Several participants attended more than one session. Please see Table 1 for a breakdown of which professionals attended each of the sessions. Of all the invited participants, all groups had a representative for the in-person discussion groups except for anesthesia, where they did not have the opportunity to contribute to the dialogue for the discussions.

Table 2.1: Stakeholder engagement session attendance for meetings held on October 10, 2019

Participants invited (n=15)	Email response	Pre-op session	Peri-op session	Post-op session

Neurosurgeon 1	x	✓	✓	✓
Neurosurgeon 2	x	✓	✓	✓
Neurosurgeon 3	x	✓	x	x
Orthopaedic Surgeon	x	✓	x	x
Anesthesiologist 1	✓	x	x	x
Anesthesiologist 2	x	x	x	x
Clinic nurse 1	✓	✓	x	✓
Clinic nurse 2	✓	✓	x	x
Nurse practitioner	✓	✓	✓	✓
OR Nurse	✓	x	✓	x
Inpatient nurse manager	✓	x	x	✓
Inpatient nurse educator	✓	x	x	✓
Inpatient nurse	✓	x	x	✓
Dietician	✓	✓	x	✓
Resident	x	✓	✓	✓
Administrative director	x	x	x	✓

List of potential strategies:

The literature review included 18 studies and revealed a total of 14 ERAS strategies (pre n=7, Table 2; peri n=6, Table 3; post n=6, Table 4). During stakeholder discussions, new strategies were added for both the pre-operative (n=3) and post-operative phase (n=4); no additional peri-operative strategies were added at this stage.

Table 2.2: Pre-op strategies discussed for potential inclusion in a spine ERAS intervention.

Strategies	**Stakeholder Discussion highlights**	**Barriers**	**Enablers**	**Consensus**
Literature (n=7)				
Patient education	Unclear how we can improve education. Possibly implement classroom sessions (like ortho does). Need something better than just a booklet. Possible spine nurse "hotline". Include patient family or caregiver in education. Possible re-iterate education prior to surgery at pre-admission clinic.	Different patients learn differently. May need multiple avenues for delivering patient education so patients get the best use out of it.	We already have a good content coverage for education with our booklet. Just need more inclusive ways to deliver it.	In
Patient expectations	Set expectations about what to expect post-operatively regarding pain management (normal vs abnormal post-op pain) and what the patient needs to achieve in order to be discharged. Include patient family member or caretaker in	Managing expectations is difficult.	Should be easier to implement with improved education delivery and more consistent messaging from hospital staff.	In

	establishing expectations for recovery and discharge.			
Fasting rules	Reducing fasting can be part of pre-op education. Not much discussion aside from easy to implement. Can drink clear fluids until 2 hours pre-op.	Changing conventional care is difficult.	Only need to change what the surgeon tells the patient.	In
Specific nutrition rules	Possible carbohydrate loading. We can possibly make our own. ERAS carbohydrate beverages exist. Identify who prepares meals for the patient. If patient lives alone, have them prepare healthy meals prior to surgery and then freeze them.	Some nutrition pre-operatively may be an added expense (ex. Carbohydrate beverages). Dietary restrictions need to be considered.	Neurosurgery has a staff dietician who is part of the ERAS protocol and already works with patients to help navigate issues surrounding specific diets and nutrition.	In
Comorbidity Medical management	Pre-op management of comorbidities. Possible education component on expectation setting with comorbidities.	Not too many barriers, already a necessary consideration for offering surgery.	Already implemented in our care.	In
Routine prophylaxis	Already use pre-op cephalosporin 1-hour prior to incision. Possible vaccination for MRSA.	No comment in email correspondence or from transcribed notes.	May possibly already be implemented in care.	In
pain management, multimodal approach	Reduction in pre-op opioid use if possible. Monitor with pre-op comorbid conditions.	Patients may be resistant to changing medications prior to surgery. Especially if narcotics are working.	None discussed.	In
Stakeholders (n=3)				
Urinary retention monitoring	Either implement a questionnaire about "normal" urinary voiding habits or purchase a bladder scanner. Currently, have purchased a bladder scanner, and plan on using this to monitor "normal" urinary retention.	Previously, had no way of monitoring urinary retention. Needed urology as a possible consult in some cases, which further delayed discharge. Purchasing a bladder scanner is expensive.	We currently have a bladder scanner purchased. Other options included asking questions pre-operatively about urinary voiding habits.	In
pre-op admission to hospital	Deemed a waste of resources, and doesn't help issues with LoS, as adds time being admitted.	n/a	n/a	Out
Integration of family or caregiver with discharge criteria.	Caregiver or family member is important for planning discharge, such as planning and coordinating patient transport, and possibly available for early discharge and also has supplies for patient when discharged. Important to implement engagement pre-operatively with patient education.	Not all patients have support systems that are able (or willing) to help them after surgery.	Patients usually bring caregiver to clinic appointments, just need to reinforce that patient education and post-op expectation setting is also communicated to them. Make them an active participant in the patient's care, along with the patient.	In

Table 2.3: Peri-op strategies discussed for potential inclusion in a spine ERAS intervention.

Potential ERAS strategies	**Stakeholder Discussion highlights**	**Stakeholder-identified Barriers**	**Stakeholder-identified Enablers**	**Consensus**
Literature (n=6)				

Peri-op multimodal pain and anesthesia.	Reduction of narcotics in the OR, introduce skin blocks for local anesthesia. Dr. Alant already does this.	Different anesthesiologists may have different training which could contribute to using different drugs, or resisting change to a new standard.	An anesthesiologist proposed intro-operative lidocaine infusions, which seems to already be used by neuroanesthesia.	In
Minimally invasive approaches when possible.	Already implemented, most surgeons already use a minimally invasive approach, or other approaches like a micro discectomy.	Not all surgeons are trained the same.	Most surgeons already do this when feasible.	In
Reduce muscle relaxants.	Helps facilitate early mobilization and recovery.	Unclear if this applies to only pre- and post-op recovery, or if also on intra-operatively.	Intra-operative muscle relaxants are unblocked by the end of surgery, so this issue does not impact recovery.	In
Restrictive use of surgical drain sites	Already implemented.	No real barriers, as it's already an approach.	Already in use.	In
IV Lidocaine infusions intraoperatively.	Found in literature and recommended by the anesthesiologist.	None	Already performed in neuroanesthesia.	In
Prevention of hypothermia with warm-air blankets.	Already implemented, normothermia monitored during surgery.	No comment during discussion on this.	Normothermia already measured during surgery.	In

Table 2.4: Post-op strategies discussed for potential inclusion in a spine ERAS intervention.

Strategies	**Stakeholder Discussion highlights**	**Stakeholder-identified barrier**	**Stakeholder-identified enabler**	**Consensus**
Literature (n=6)				
Chewing gum	Likely not beneficial for musculoskeletal disease.			Out
Discontinue indwelling foley catheter by 6:00am day 1.	Possibly look at avoiding indwelling catheters completely if possible. Possible consult with urology if catheter necessary. Need a better protocol for monitoring urinary retention. Currently have a bladder scanner, so this is improved now.	May not be possible if we can't monitor how much is "normal" per patient regarding urinary retention.	Currently with a bladder scanner and with the healthcare team checking this at 6am rounds, this can be easier to implement.	In
Standard PCA pump.	Might not be necessary (or helpful) in spine. Make a decision between anesthesia and neurosurgery patient by patient before surgery to see if warranted. Can be combined with medical optimization of comorbidities. Also issue of resources as PCA pumps are limited.	n/a	n/a	Out

Post-op multimodal analgesia (eg. alternative medications only)	Reduction on narcotics post-operatively. Have a standard for when narcotics are offered via a visual analogue scale (such as a 7+/10). Possibly have less types of narcotics on PPO and more non-narcotic alternatives. An anesthesiologist proposed having Celebrex and gabapentin as optional check boxes as opioid alternatives, and leave them as check boxes so they aren't automatically ordered every time. That way patients who don't have an indication for them don't automatically receive them.	Possible barriers include some medications which patients could be allergic to if we put them on a PPO.	Easy to implement and prescribe. Changing PPO to include more multimodal medications as opposed to a few narcotics makes it more work to order opioids and more likely to order alternatives.	In
Early mobilization	Can be combined with patient education/expectation setting. Set goals for the patient to achieve to help facilitate discharge. Typically, physio does this, however nursing is also qualified to help early mobilization. Need nursing education to make this clear. Have clear distance guidelines within day of surgery, and distance to travel on post-op day 1.	Physiotherapy and nursing may be resistant to doing this based on the patient's recovery schedule. Particularly physio. Nursing typically prefers physio do the first mobilization. Currently mobilization is done more as when it is convenient for physio.	Nursing manager and educator are on board. Willing to re-educate nursing to make this a component of care.	In
Early nutrition	Able to drink clear fluids within two hours of surgery. Return to normal diet as early as tolerated.	Patients are fed at standardized time.	Having a checklist for what a patient needs to achieve after surgery can help facilitate the patient and nurse to proactively follow this.	In
Stakeholders (n=4)				
Personal post-op laminated goals sheet	List of goals both the patient and healthcare team need to abide by in the patients room. Ex. Patient needs to mobilize with healthcare team, as well as periodically on their own if possible. Also include dietary goals. Make sure these goals are clearly defined pre-operatively during patient education.	Not sure if patients/care team will use them. Cost extra time and money, even if it is minimal.	Easy to implement and provide with patient charts, or even as a white board in the patients room.	In
Ensuring bowel regime is followed as per preprinted orders.	Senna 2 tabs automatically provided when ordering medications for the patient.	No barriers, already monitored.	Already monitored and followed at our site.	In
Intake further CHO or protein/energy rich supplements	Identify if a high protein diet is necessary to help facilitate recovery. Otherwise, general diet supplied.	Potential further costs for purchasing carbohydrate beverages.	Many patients are already provided ensure drinks post-operatively if they aren't able to resume normal nutrition. So, product is readily available.	In

Over the phone follow-up with patient 7-10 days discharge.	Helps monitor possible re-admission complications.	Takes up clinic nurses limited time. Busy clinics may mean patient calls are missed. Patients don't always respond to hospital staff calling them.	Clinic already has phones, and the administrative director said time and space can be provided to help facilitate this resource.	In

Strategy discussion groups (Tables 2.2-2.4):

Consensus was reached to include a total of 23 strategies and omit three. After thorough discussion of each identified strategy, we determined that many were, in fact, easy to implement at our site. For example, comorbidity medical management and intraoperative use of lidocaine infusions were already expressed to be part of standard care at our site; however, an audit would need to be performed to confirm that.

However, other strategies faced barriers due to cost (e.g., purchasing a bladder scanner) but were considered feasible to implement once the financial barrier was mitigated. Finally, some strategies (e.g., changing care delivery from nurses or allied health (such as occupational or physical therapy) faced operational challenges. Mitigators to this included working with our nurse educator and having the nurse manager champion and help facilitate these operational challenges.

Other strategies required more discussion before the group decided to include them. These strategies were deemed beneficial to implement but were perceived to have potential barriers that would require mitigation. For example, reduction of narcotics was found to be practical, affordable, and acceptable, but also considered unsafe to apply to patients addicted to narcotics. Similarly, while implementation of one of the specific nutrition rules (i.e., carbohydrate beverage) was considered practical, acceptable and

reasonable to include, particularly since it is already used post-operatively for patients with dietary issues, there were concerns about affordability of implementing this strategy for all patients prior to surgery.

Discussion

Our stakeholder discussion groups resulted in the inclusion of 23 of the 26 pre, peri, and post-operative strategies reviewed during these sessions. After evaluating the identified strategies in our group discussions, we identified three strategies that could not be included or that required further study. Eight strategies (e.g., optimization of comorbidity medical management, routine prophylaxis, or use of minimally invasive approaches when feasible) were identified as part of our routine management by stakeholders, however, this was not measured before or after the stakeholder sessions, so it is not known if this is always true or not. Other strategies were recommended for inclusion, but represented a barrier for our site. For example, while a bladder scanner was recommended to accurately measure urinary retention for determining catheter requirements and potential for discharge, the barrier to implementation was cost to procuring the bladder scanner.

Implications for practice and research:

Various groups either did not attend the in-person discussion sessions (anesthesiology) or were not invited to participate in the development of the ERAS protocol at all, those being physiotherapy and occupational therapy. We may have missed an opportunity to discuss barriers and enablers for specific anesthesia recommendations for ERAS as well as more physically oriented ERAS strategies, such as early mobilization, with physiotherapy and occupational therapy. While most included stakeholders have a direct

affiliation with spine surgery, physiotherapy and occupational therapy at the QEII work on multiple floors and units, and are not spine specific, making it challenging to identify staff who could contribute to these discussions.

Stakeholders involved in our group discussions suggested adding 15 additional strategies to our routine management to form a comprehensive ERAS intervention. This will impact the practice behaviours of multiple types of providers/all providers involved in spine surgery care. Some of these strategies will require only minimal changes to existing duties and/or practice (e.g., restricting the use of drains and catheters), while others will require more substantive changes (e.g., introduction of early mobilization and early nutrition). Healthcare systems will have to make decisions on how they will support these behavior changes, particularly around those that are more complicated. For example, the purchase and use of a bladder scanner to measure urinary retention is thought to be an important strategy to implement as it may have major benefits for patients undergoing spine surgery by preventing delayed discharge and unnecessary catheterization. However, a bladder scanner is an expensive piece of machinery and implementing its use requires significant consideration. It will require staff training to operate the scanner and change in routine practice. Before implementing this strategy, it is, therefore, imperative to fully understand the prevalence of the urinary retention problem so that we can determine if the cost of the purchase and implementation of this strategy is worthwhile.

Even among the recommended strategies that are already a part of standard practice at our site, additional work is required. For example, patient education at our site requires a significant overhaul in order to implement this strategy in the manner it which it was

discussed by our stakeholders. Developing new patient education materials can be a timely and expensive endeavour if done correctly. Multiple guidelines exist for the appropriate design/co-design of patient education materials (McDonald et al., 2023). Briefly, the steps involved include reviewing the literature to identify information and education needs, consulting with experts at our institution to identify patient education needs and engaging with patients to determine their information needs and how they would like to receive this information. Once these education and information needs have been confirmed, implementation of new patient education materials will require proper staffing to ensure that the information is translated in materials that are readable, understandable, actionable, and that use graphics that adhere to these same principals. This is a considerable undertaking that requires planning and that must be appropriately resourced.

Thus, future work would include assessing the prevalence of the problems new strategies are meant to address, co-developing patient education materials (i.e., conducting a needs assessment), holding patient/stakeholders engagement sessions, and assessing patients' perspective on reasons for non-discharge.

Strengths and Limitations:

This discussion group is strengthened by the participation of a diverse group of healthcare professionals. The stakeholder discussion groups we conducted included all types of health professionals working directly in our spine surgery program who deliver care in each of the three surgical phases (pre-, peri-, and post-operative). However, relevant healthcare professionals involved in caring for spine surgery patients, but working in

other departments, were not invited to participate in these sessions. For example, no representatives from physiotherapy or occupational therapy were involved. Due to this, potential logistical, clinical or technical issues related to the delivery of some ERAS strategies may not have had all relevant perspectives on actually implementing the strategy.

The work is further strengthened by its rigorous planning and facilitation as suggested by Doria et al (2018). We used a very structured process to engage our stakeholders in discussion groups. We prefaced each meeting by compiling a comprehensive list of recommended spine surgery ERAS strategies which was sent to discussion group invitees in advance of the meeting for their review. At the meeting itself, we had a structured process of examining each strategy and making decisions on their inclusion before moving on to the next strategy. In addition, we had the evidence supporting each strategy available for review and discussion for those who questioned the efficacy of strategies presented.

In hindsight, it would have been most rigorous to have audio-recorded our stakeholder engagement session. However, we took detailed field notes at each session and presented a summary of the session results at the end of each discussion so that participants could provide any corrections they felt were necessary about the results of the discussion group.

Conclusion:

We followed best practice guidelines for intervention development by engaging with appropriate stakeholders. Engaging with a diverse group of healthcare professionals

allowed us to work together to identify and evaluate a comprehensive list of potential strategies for inclusion in an elective spine surgery ERAS intervention. This stakeholder engagement session was important for gaining consensus on for which strategies were omitted and which strategies require more work to determine feasibility.

Funding:

A Translating Research Into Care (TRIC) Grant was obtained in 2019, valued at $3000, for this project from the QEII Foundation Healthcare Improvement Research Program. This funding was used to cover travel expenses for Dr. Wainwright.

Chapter 3 : The Effect of Enhanced Recovery After Surgery Protocols for Elective Cervical and Lumbar Spine Procedures on Hospital Length of Stay: A Systematic Review and Meta-Analysis

Authors: Ryan Greene[1,2], Bradley Furlong[1], Jenna Smith-Forrester[2], Michelle Swab[3], Sean D. Christie[2], Holly Etchegary[1], and Amanda Hall[4]

Affiliations:

1. Faculty of Medicine, Memorial University of Newfoundland, St. John's, NL, Canada

2. Department of Surgery (Neurosurgery), Dalhousie University, Halifax, NS, Canada

3. Health Science Library, Faculty of Medicine, Memorial University of Newfoundland, St. John's, NL, Canada

4. Primary Healthcare Research Unit, Memorial University of Newfoundland, St. John's, NL, Canada

Co-authorship Statement

As the primary author, I contributed to the study design, acquisition of the papers for review, and reviewing them. I also abstracted the data, analyzed and interpreted it, and wrote the manuscript. Mr. Furlong contributed to reviewing the papers in the review, and also assisted with data abstraction. Dr. Smith-Forrester contributed by reviewing the papers from the review. Ms. Swab contributed by providing the search string for this review. Dr. Christie and Dr. Etchegary contributed to the study design, as well as reviewed the final manuscript. Dr. Hall contributed to the study design, data abstraction, interpreting the results, and writing and reviewing the manuscript.

Introduction

Length of hospital stay after surgery is a problem for many surgical procedures. For example, following colorectal surgery, an expected length of stay (LoS) for a colonic resection has been reported as 9-10 days (Ljungqvist, 2014). Importantly, each day in hospital is associated with 5% higher likelihood of systemic complications (Mathew et al., 2018) such as urinary tract infection, as well as surgical site infections (Dagal et al., 2018). Furthermore, prolonged LoS contributes significant cost to the health care system (Mathew et al., 2018) and to a reduction of available hospital beds.

Enhanced recovery after surgery (ERAS) is an intervention that employs strategies across the three surgical stages (pre-, peri- and post-) to improve a patient's post-operative course. A patient's recovery is typically defined by when they are able to mobilize, manage their pain, and resume normal diet. Classically, ERAS strategies include detailed patient education material, reduction of narcotics in the operating room, and optimized post-operative early mobilization techniques (Ljungqvist et al., 2017). Selected strategies vary from one intervention to another and may be limited by hospital-based resources. The combination of strategies aims to facilitate improved recovery for patients, which should in turn result in reduced LoS, without increasing re-admission to hospital.

Currently, ERAS protocols are widely implemented across surgical specialties, including colorectal (Gustafsson et al., 2019), gynecologic (Nelson et al., 2019), total hip and knee replacement (Wainwright et al., 2020) and urologic surgery (Cerantola et al., 2013). The effectiveness of ERAS interventions in these areas has been evaluated in several randomized control trials (RCTs) and recent systematic reviews of this evidence indicate

modest reductions in LoS (Sauro et al., 2024). For example, Parisi et al. (2020) found a significant decrease of -0.51 (95% CI: -0.92 to -0.10, p=0.001) days in LoS for five randomized control trials (RCTs) related to bariatric procedures, and Zhang et al. (2020) found a significant decrease of -1.12 (95% CI: -1.80 to -0.45, p=0.001) days for patients who received an ERAS intervention for radical cystectomy in seven RCTs.

Only recently have there been formal guidelines specifically describing ERAS for lumbar spine procedures (Debono et al., 2021a). Current systematic reviews of ERAS for spinal surgery have been primarily narrative and included heterogenous patient pathologies (deformity, tumor, and degenerative disease) (Elsarrag et al., 2019; Dietz et al., 2019; Tong et al., 2020, and Pennington et al., 2020), making the interpretation for the effect of ERAS on degenerative spine disease and elective surgery difficult. While this evidence has narratively shown that ERAS may reduce LoS, these studies did not perform risk of bias assessments (Elsarrag et al., 2019; Pennington et al., 2020), nor adhere to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) (Elsarrag et al., 2019). Studies used limited search strategies (Elsarrag et al., 2019; Dietz et al., 2019; and Tong et al., 2020), did not synthesize data for a meta analysis (Elsarrag et al., 2019; Dietz et al., 2019; Tong et al., 2020) or use the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) criteria (Elsarrag et al., 2019; Dietz et al., 2019; Tong et al., 2020; Pennington et al., 2020). Further, since the last review, at least seven new ERAS studies for spinal surgery have been completed; thus, an update is needed. The aim of this study is to determine the effect of implementing an ERAS intervention for patients undergoing elective spine surgery for degenerative pathologies

on length of stay after their procedure and re-admission to hospital within 30-, 60- or 90-days post-discharge.

Methods

Design: A systematic review and meta-analysis was performed in accordance with the Cochrane Handbook for Systematic reviews of Interventions (Cochrane Handbook for Systematic Reviews of Interventions, 2022) and PRISMA guidelines (Shamseer et al., 2015).

Search Strategy: We employed the Peer Review of Electronic Search Strategies (PRESS) guidelines to develop the search strategy (Appendix 3.1), developed in consultation with a health research librarian (MS). We conducted the search in three databases: PubMed, CINAHL and Embase from inception to November 23rd, 2021. To supplement the electronic search, we used forward and backward citation tracking.

Selection Process and criteria: The search was conducted by RG and downloaded to Covidence Software (Covidence systematic review software, Veritas Health Innovation, Melbourne, Australia, accessed November 23rd, 2021) where duplicates were removed automatically. The remaining studies were independently screened by two reviewers (RG and JSF) at both the title/abstract and full text stages using pre-defined eligibility criteria for each of the Population, Inclusion, Comparator, and Outcomes (PICO) framework elements (Table 3.1). In all cases, where discrepancies in decision making were found, a third reviewer (SDC or AH) decided if the study was included or not.

Table 3.1: Population, Inclusion, Control and Outcome (PICO) Table for the studies inclusion/exclusion criteria.

	Inclusion Criteria	Exclusion Criteria
P	All patients 18 years of age and older undergoing elective spine surgery for posterior cervical and lumbar fusion procedures.	Spine surgery for trauma, deformity, tumour, or acute back pain. Day surgery and surgery using minimally invasive techniques were excluded.
I	Implementation of an enhanced recovery after surgery program for spinal surgery. The program will involve the development of a pathway optimizing the patients care during the pre-, peri-, and post-operative phases of surgery.	Exclusion criteria included studies which only partially implement ERAS.
C	Standard care for posterior cervical and lumbar fusion procedures.	
O	Length of stay will be the primary outcome. Re-admission rate to hospital, and cost per patient will be secondary outcomes.	Studies which don't include total hospital length of stay, or only provide cost saved after implementing ERAS.
Design	Randomized control trials, cohort studies and retrospective studies will be included.	Qualitative studies.

Data extraction process and data items: One author (RG) extracted data from the included studies, with a second author (BF) checking the data for any potential errors. Data items included author, publication year, sample size, study design, patient age, BMI and sex, patient pathology, type of surgical procedure, ERAS intervention characteristics using items from the template for intervention description and replication (TIDieR), comparison group components, outcome information for length of stay and readmission rate. Information on intervention fidelity was also extracted. Fidelity was defined as

percentage of adherence to either each phase in the protocol (pre-, peri- and post-operative phases), or to each individual component, such as adherence to early mobilization, reduction of peri- and post-operative narcotics, and patient education.

Risk of bias assessment: The Risk Of Bias In Non-Randomized Studies-of Interventions (ROBINS-I) assessment tool was used to assess bias for all non-randomized studies (Sterne et al., 2016). This included assessment of bias due to confounding, selection of study participants, classification of intervention, deviations from the intended intervention, missing data, measurement of outcomes, and selection of the reported results. Importantly, for confounding, if a study had formal control groups, or used a statistical methodology (such as propensity matching) to ensure comparator groups were similar, risk of bias was judged to be low or moderate. If the study did nothing to control for confounding, a serious risk of bias was assessed. For measurement of the outcome, a lack of blinding for assessors of the intervention would contribute to a higher risk of bias being assessed. Deviations from the protocol were assessed if adherence to ERAS interventions was reported. One author (RG) assessed RoB and a second author (BF) checked RoB assessment for errors, and a third reviewer (AH) was consulted a if a decision on RoB could not be attained independently. Each paper received an overall RoB assessment of low, moderate, serious, or critical risk of bias based on ROBINS-I recommendations.

Data analysis:

Meta-analysis and measure of treatment effect: A random effects model was used for the meta-analysis, as ERAS interventions of the included studies used different components

and delivery methods. To measure heterogeneity, the I^2 value was used, and we used a value of 75% or higher to represent high statistical heterogeneity warranting consideration of appropriateness to pool the data in a meta-analysis (Higgins et al., 2003). Length of stay was extracted with means and standard deviations. Days was chosen as the measure of treatment effect; thus, outcomes reported in hours were converted to days for the meta-analysis. A weighted mean difference in LoS was reported for this meta-analysis. Similarly, re-admission rates to hospital (within 30-, 60- or 90-days of discharge) were also recorded as frequencies and percentages and meta-analyzed independently. Cost effectiveness was captured as a quality adjusted life year (QALY). For the meta-analyses, frequency of re-admission in each group (ERAS or control) was reported out of the total sample of each group. Odds ratios (OR) were reported for the outcome of interest, as the odds of being re-admitted to hospital favouring either the control group (odds ratio>1) or the ERAS group (odds ratio<1). In the event missing data was found for a particular study (such as missing standard deviations or specific number of re-admissions), the corresponding author was contacted in an attempt to obtain the missing information in order to perform the meta-analysis with that data.

Basic descriptive data (Measurement tool, time point and metric) will be extracted on secondary outcomes, such as the functional ability, opioid consumption, urinary retention, pain, re-operation, post-operative complications, patient satisfaction and nutrition. No data will be abstracted on the effect size, and will be used for descriptive purposes only, and could be used for the planning of future meta-analysis.

Data Synthesis:

We evaluated the certainty of the pooled estimate using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach (GRADE Handbook, 2022). The GRADE approach includes four levels of certainty: high, moderate, low or very low. Typically, certainty in the evidence starts at the level of high and is then downgraded based on five factors: (i) methodological quality, (ii) inconsistency in the results, (iii) indirectness of evidence, (iv) imprecision of evidence and (v) Publication Bias. However, for intervention effectiveness questions, this method is typically applied to RCTs. When the pooled estimate is derived from non-randomised study designs, GRADE recommendations consider confounding and selection bias as justification to start the certainty level at a level of low, and then be further downgraded if needed (Schünemann et al., 2018). The GRADE criteria assess for publication bias descriptively, by examining author affiliations with companies and conflicts of interest, as well as funding for the project identified in the paper.

Results:

Electronic database searches in PubMed, Embase, and CINAHL generated 2395 records of which, 1217 of these were duplicates, resulting in 1178 records being examined for title/abstract screening. After title/abstract screening, a further 1133 papers were removed, primarily for not being related to spine surgery or to the ERAS intervention, leaving 45 studies that were examined in a full text review for eligibility, 12 of which were included (Figure 3.1). Papers were excluded largely due to not having the correct patient population. A total of four studies were excluded due to language and not being available in English. These studies were written in Chinese (n=2), Spanish (n=1), and German (n=-1).

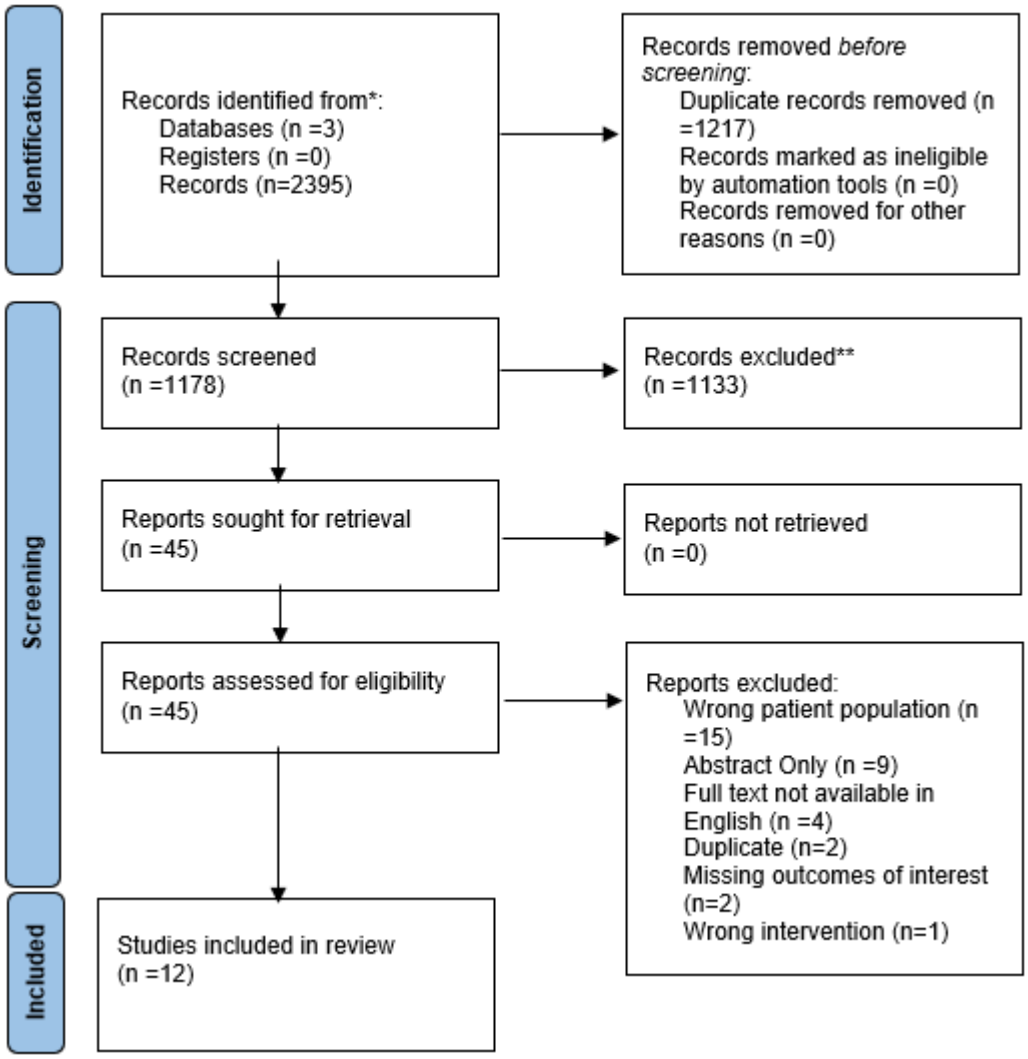


Figure 3.1: PRISMA flow diagram for studies included for the review.

Study characteristics

Eligible studies were from the United States (Bradywood et al., 2017; Flanders et al., 2020; Heathcote et al., 2019; Kerolus et al., 2021; Smith et al., 2019), France (d'Astorg et al., 2020; Debono et al., 2019; Debono et al., 2021b), China (Duojun et al., 2021; Li et al., 2018; Li et al., 2021) and India (Garg et al., 2021) (Table 3.2). All studies were uncontrolled 'before and after studies', and included a comprehensive ERAS pathway,

with a protocol that contained proposed improvements in the pre-, peri- and post-operative phase of a patient's care. The comparator in each study was standard of care prior to implementing an ERAS protocol. All studies focused exclusively on procedures related to spine surgery, with the exception of one that implemented ERAS over multiple surgical departments, as well as spine (Flanders et al., 2020). Six studies focused exclusively on lumbar procedures (Bradywood et al., 2017; Duojun et al., 2021; Garg et al., 2021; Kerolus et al., 2021; Smith et al., 2019), while two studies focused exclusively on surgery related to the cervical spine (Debono et al., 2021b; Li et al., 2018). The remaining studies included a combination of pathologies related to either the lumbar or cervical spine (d'Astorg et al., 2020; Debono et al., 2019; Flanders et al., 2020; Heathcote et al., 2019). All studies recorded LoS as an outcome, primarily reporting days as the metric, except for one study reporting in hours (Smith et al., 2019). Nine out of twelve studies recorded re-admission to hospital; however, the reporting varied, as some chose to report 30-day (Bradywood et al., 2017; d'Astorg et al., 2020; Debono et al., 2021b; Flanders et al., 2020; Garg et al., 2021; Kerolus et al., 2021; Li et al., 2018), 60-day (Garg et al., 2021) or 90-day (Debono et al., 2019; Debono et al., 2021b; Flanders et al., 2020) re-admission. While Heathcote et al. (2019) reported re-admission to hospital, they did not include the follow-up period after surgery. No studies measured cost effectiveness.

Table 3.2: Characteristics of included studies, based on study design, pathology, surgery offered, ERAS intervention, comparison as well as outcomes reported.

Study, Year, Country Design	**Patient pathology*** **Types of surgical procedures**	**ERAS Intervention**	**Outcomes Assessed (Y/N)**		
			LoS	**Re-admission**	**Cost** QALY
Smith 2019. USA. UBA	Lumbar - All 4 pathologies*. Decompression + fusion	Pre-op: Post-op discharge plan. Peri-op: Pre-op antibiotic ordered. Post-op: All patients receive stool softeners, discontinue foley, diet as tolerated, PT evaluate patient mobilization needs. Early mobilization.	Y	N	N
Li 2018. China. UBA	Cervical - myelopathy Decompression	Pre-op: Education, reduced fasting. Peri-op: Primary use of NSAIDs for medication. Post-op: Regular diet as tolerated, early mobilization.	Y	N	N
Bradywood 2017. USA. UBA	Lumbar - Stenosis, Spondylolisthesis Decompression + fusion	Pre-op: Smoking cessation, optimize nutrition, chlorhexidine showers 3 days before surgery, Peri-op: Reduction in drains/catheters. Post-op: Early mobilization, and early nutrition.	Y	Y (30 days)	N
Debono 2021. France. UBA	Cervical - Spinal stenosis Decompression + fusion	Pre-op: Education about mobilization and ERAS protocol. Further online education. Reduced fasting. Peri-op: No routine drains. Post-op: Early mobilization with physiotherapy,	Y	Y (30 and 90 days)	N
Debono 2019. France. UBA	Lumbar or Cervical - Spinal stenosis, disc herniation, myelopathy Decompression + fusion	Pre-op: Education about mobilization and ERAS protocol. Further online education. Reduced fasting. Peri-op: Opioid sparing approach, pre-emptive analgesia. Post-op: Early mobilization with physiotherapy,	Y	Y (90 days)	N
d'Astorg 2020. France. UBA	Lumbar - disc herniation, spinal stenosis. Cervical - myelopathy Decompression + fusion	Pre-op: Multi-disciplinary education with doctors. Post-op discharge instructions. Peri-op: Opioid sparing, as few drains and catheters as possible. Post-op: Early mobilization, early discharge and post-op phone call when discharged,	Y	Y	N
Flanders 2020. USA.	Cervical or Lumbar - All 4 pathologies*	Pre-op: Patient education, nutrition optimization, smoking and alcohol cessation, discharge planning.	Y	Y (30 and 90 days)	N

UBA	Decompression + fusion	Peri-op: Metabolism management, multimodal analgesia, surgery checklist. Post-op: Early mobilization, wound care management.			
Heathcote 2019. USA. UBA	Decompression + fusion	Pre-op: Optimize medical conditions, nutrition assessment, carbohydrate loading. Peri-op: Reduction of narcotics. Post-op: Early mobilization, early nutrition, limited opioids, multimodal oral analgesics.	Y	Y	Y
Duojun et al., 2021. China. UBA	Cervical and Lumbar - Disc herniation. Decompression	Pre-op: patient education, reduced fasting, skin cleaning. Peri-op: Prevention of hypothermia, local anesthesia to prevent post-op incision pain. Anesthesia monitoring. Post-op: Opioid avoidance, primary use of NSAIDs for pain management. Patient specific nutritionist plan. Early mobilization and lumbar exercises.	Y	N	Y
Garg et al., 2021. India. UBA	Cervical or Lumbar - All 4 pathologies[+] Decompression + fusion	Pre-op: Improved patient education, reduction in patient wait list once offered surgery. Prehabilitation program and reduced fasting. Pre-operative carbohydrate loading and chlorhexidine showers. Peri-op: Standardized anesthesia, avoidance of hypothermia. Safe surgery checklist. Post-op: Early drain and foley removal. Early mobilization and nutrition. Multimodal analgesia.	Y	Y (60 days)	N
Kerolus et al., 2021. USA. UBA	Cervical or Lumbar - All 4 pathologies. Decompression + fusion	Pre-op: patient education, reduced pre-op fasting. Peri-op: Minimize drains, reduction of opioid use. Post-op: Multimodal analgesia, early mobilization + specific discharge criteria, opioids only for specific pain scores.	Y	Y (30 days)	N
Li et al., 2021. China. UBA	Cervical or Lumbar – Stenosis Decompression + fusion	Pre-op: Improved patient education, reduced fasting and nutritional screening with dietician. Peri-op: Standardized analgesia, maintenance of normothermia. Post-op: Early ambulation, removal of catheters, oral feeding. Multimodal analgesia and definitive discharge criteria.	Y	Y (30 days)	N

*any of the following 4 chronic spinal pain conditions: spinal stenosis, myelopathy, spondylolisthesis, disc herniation.

[+]degenerative disc disease, facet joint cyst

Description of ERAS intervention and intervention fidelity:

Each study described a unique approach to implementing the ERAS intervention. Pre-operative and post-operative phases were particularly different regarding implementation strategies for ERAS in each study (Table 3.3). However, there was much greater consistency across studies regarding the strategies employed in the peri-operative phase.

Table 3.3: Description of the ERAS intervention per study, and assessment of adherence to the intervention if reported.

Study / year	**Intervention components including materials used and who delivered**	**Fidelity assessment performed?**	**Fidelity assessment result**
Smith et al., 2019. United States.	Pre: Screening for comorbidities and tailored care to pre-existing disease. Pre-op antibiotic ordered.	No	N/A
	Peri: Identify patients' high risk for pain management. Reduction of narcotic medications if possible, based on pain tolerance.	No	N/A
	Post: Patients receive stool softener and diet if tolerable on day 0. On day 1, discontinue foley and facilitate patient mobilization. Discontinue surgical drain on day 2 if possible.	Yes	Recorded 78% and 81% compliance with post-op analgesia with oral gabapentin and acetaminophen respectively.
Li et al., 2018. China.	Pre: Pre-op education, no pre-op bowel treatment and reduced fasting period (12 hours to 6)	Yes	100% Compliance to education, no bowel preparation, and reduced pre-op fasting.
	Peri: No standard of peri-op analgesia, adaptive based on the patient.	Yes	92.11% adherence to local anesthesia during surgery, and 100% adherence to oral and schedules intravenous analgesia. A 62.8% adherence to an analgesia infusion pump was observed.

	Post: Regular diet after removing anesthesia, early off bed mobilization, removal of catheter on day 1, remove drain wound on day 2.	Yes	Over 90% adherence for early diet, removal of wound drainage (post-op day 2), antithrombotic prophylaxis, and early mobilization. For early removal of catheterization, an adherence of 86.84% was observed.
Bradywood et al., 2017. United States.	Pre: Reduction in pre-op narcotics. Smoking cessation, chlorhexidine showers, and co-operative patient discharge plan. Patient discharge plan done with family/caretaker. Big focus on making the patient a part of their own recovery.	No	N/A
	Peri: Early discontinuation of opioids during surgery.	No	N/A
	Post: Specific patient goals for nutrition and early mobilization. Specific goals for the patient to reach to get discharged. Patient cleared for x-rays and can pass gas and pain is tolerated.	No	N/A
Debono et al., 2021b. France.	Pre: Pre-op physio education with fast-track nurses. Online pre-admission education. Anti-infection strategies and reduced fasting.	No	N/A
	Peri: Reduction in narcotics during surgery if possible. Focus on reduction in muscle relaxants as that is counterproductive to post op mobilization. Urinary catheter removed as soon as operation finished.	No	N/A
	Post: Early mobility with physio, opioid sparing approach, pre-emptive analgesia with no routine drain. Included post-op counselling and follow-up plus patient satisfaction.	No	N/A

Debono et al., 2019. France.	Pre: Pre-op physio education with fast-track nurses. Online pre-admission education. Anti-infection strategies and reduced fasting.	No	N/A
	Peri: Reduction in narcotics during surgery if possible. Focus on reduction in muscle relaxants as that is counterproductive to post op mobilization. Urinary catheter removed as soon as operation finished.	No	N/A
	Post: Early mobility with physio, opioid sparing approach, pre-emptive analgesia with no routine drain. Included post-op counselling and follow-up plus patient satisfaction.	No	N/A
d'Astorg et al., 2020. France.	Pre: Multi-disciplinary consultation with surgeons, anesthesia, nurses and physio. Post-op directives and patient education.	No	N/A
	Peri: Opioid sparing approach, as few catheters and drains as possible.	No	N/A
	Post: Early mobilization on day 0 and discharge if possible. Patient at home on day 1, with post-op phone call.	No	N/A
Flanders et al., 2020. United States.	Pre: Standardized written education on ERAS and their surgery. Nutrition consultation for patients if needed (eg. Diabetes or high/low BMI). Patients needing opioids referred to pain management. Smoking cessation. Patients instructed to carbohydrate load pre-op.	Indirectly	Showed a reduced pre-operative usage of narcotics. Unclear if narcotic use was medically necessary, or if it was related to not adhering to the protocol.
	Peri: Combination of opioid and non-opioid meds provided intro operatively.	Indirectly	Showed greater usage of a foley intra-operatively, with less use post-operatively.

	Muscle relaxants provided as needed.		
	Post: Patients provided chewing gum 3 times a day. Post-op early mobilization from physio/nursing team within 6 hours surgery. Bed exercises if patient can't walk. Ambulation encouraged up to 5 times a day unless surgeon restricted. Early nutrition and patients eating sitting up. Patients encouraged to wash wounds daily.	Indirectly	Reported the percentage of people who used opioids after surgery between control and the ERAS group, and showed a reduction in narcotic medications. Also exhibited improved mobilization after surgery, however it is unclear if cases where ambulation was not achieved was due to patient limits or poor adherence. Also showed a reduction in foley use, but not specifically adherence.
Heathcote et al., 2019. United States.	Pre: Pre-op management of comorbidities. Nutrition assessment. Carbohydrate loading prior to surgery. Pre-operative medications provided.	No	N/A
	Peri: Lidocaine/ketamine infusion, limited opioids provided.	No	N/A
	Post: Early mobilization, rapid diet advancement, catheter removal on day 1, provided oral analgesics if tolerated over IV with continued reduction in opioids.	No	N/A
Duojun et al., 2021. China	Pre: Improved education program and counseling. No fasting water and pre-op area skin cleaning.	No	N/A
	Peri: Prevention of hypothermia protocols, local anesthesia to prevent post-operative incision pain. Anesthesia monitoring.	No	N/A
	Post: Opioid avoidance, and primary use of NSAIDs. Nutritionist developed nutrition plan. Mobilization	No	N/A

	within 3 hours post-op. Post-op lumbar exercises.		
Garg et al., 2021. India.	Pre: Improved patient education, and patients provided former patient testimonials. Improved efficiency on wait lists after being offered surgery. Targeted optimization of comorbidities by anesthesiology. Protein supplementation for poorly nourished patients. Prehabilitation program. Improved pre-op fasting and carbohydrate loading. Chlorhexadine shower night and morning before surgery.	No	N/A
	Peri: Standardized anesthesia, decreasing need for opioids. Avoidance of hypothermia. Safe surgery checklist.	No	N/A
	Post: Early drain and foley removal. Early mobilization and early nutrition. Multimodal analgesia, reducing need for opioids. Patient motivated for early discharge.	No	N/A
Kerolus et al., 2021. United States.	Pre: Improved patient education. Reduced pre-op fasting, and pre-anesthetic medication.	No	N/A
	Peri: Minimize drains, reduce opioid use.	No	N/A
	Post: Multimodal analgesia, early mobilization, criteria-based discharge. Opioids only provided based on patient specific pain scores.	No	N/A
Li et al., 2021. China.	Pre: Improved patient education, also provide education on ERAS pathways and why it is beneficial. Nutritional screening with a dietician. Reduced fasting. Antibiotic	Yes	Patient education (100%) Nutritional counselling (100%) No prolonged fasting (100%)

	prophylaxis 1-hour prior to surgery.		Fluid and carbohydrate loading (98.3%) Antithrombotic stocking (96.7%) Antimicrobial prophylaxis (100%)
	Peri: Standardized anesthesia, and routine use of a local analgesia. Maintenance of normothermia.	Yes	Tranexamic acid (100%) Avoidance of salt and water overload (100%) Maintenance of normothermia (100%) local infiltration analgesia (100%)
	Post: Early ambulation (within 4 hours post-op), early removal of catheter, early oral feeding. Post-op multimodal analgesia with reduced need for opioids. Definitive discharge criteria.	Yes	Early ambulation (70.0%) Early removal of bladder catheter (86.7%) Early oral feeding (80.0%) Stick to discharge criteria (78.3%) Perioperative multimodal analgesia (100%)

Pre-operatively, patient education was ubiquitous; however, the delivery content and approach differed across studies. For example, some opted for written information (Flanders et al., 2020; Garg et al., 2021; Li et al., 2021; Smith et al., 2019), or in person with a healthcare provider (Bradywood et al., 2017; d'Astorg et al., 2020; Debono et al., 2019; Debono et al., 2021b; Duojun et al., 2021; Garg et al., 2021; Heathcote et al., 2019; Li et al., 2021). Of these, one study also provided education for the patient's family/caretaker (Bradywood et al., 2017). Furthermore, one study provided patient education through an online tool (Debono et al., 2019). Pre-operatively, some studies chose to address carbohydrate loading (Flanders et al., 2020; Garg et al., 2021; Heathcote et al., 2019; Li et al., 2021), which has been shown to help facilitate post-operative mobilization. Many studies also opted to reduce fasting time in the leadup to surgery

(Debono et al., 2019; Debono et al., 2021b; Duojun et al., 2021; Garg et al., 2021; Kerolus et al., 2021; Li et al., 2021).

The peri-operative phase demonstrated the least variation, with all studies having focused on reducing narcotics, albeit in unique ways. For example, some studies limited narcotics used in the operating room or only provided them as necessary (d'Astorg et al., 2020; Debono et al., 2019; Debono et al., 2021b; Duojun et al., 2021; Flanders et al., 2020; Garg et al., 2021; Heathcote et al., 2019; Kerolus et al., 2021; Li et al., 2021), while others had narcotic cessation early on during surgery (Bradywood et al., 2017). The last approach was to identify patients with poor pain management pre-operatively to provide a personalized pain management program (Li et al., 2018; Smith et al., 2019). Several studies also made an effort to not use, or at least reduce, usage of a foley catheter if possible (d'Astorg et al., 2020; Debono et al., 2019; Debono et al., 2021b; Garg et al., 2021; Kerolus et al., 2021; Li et al., 2021).

Post-operatively, all studies tried to provide patient mobilization as early as possible after surgery. Most studies induced early mobilization via sitting up in bed or walking as early as tolerated. While similar, Duojun et al. (2021) used in-bed exercises to begin their mobilization process. Post-operative nutrition was also an important component in the identified studies, with some opting for an immediate return to normal diet after surgery (Flanders et al., 2020), whereas others increased nutritional intake on the first day of recovery (Heathcote et al., 2019). Duojun et al. (2021) even utilized a nutritionist to plan individualized post-operative nutrition plans as opposed to only planning for earlier introduction of eating/drinking.

Fidelity was lacking overall, in regard to whether adherence was reported or not, with only four studies (Flanders et al., 2020; Li et al., 2018; Li et al., 2021; Smith et al., 2019) reporting measurement of adherence to the ERAS protocol. Of these, three of the studies (Flanders et al., 2020; Li et al., 2018; Li et al., 2021) measured fidelity at all three phases of the ERAS intervention, whereas Smith et al. (2019) only discussed adherence in the post-operative phase of their pathway. Of the four studies included, only Li et al. (2021) had detailed breakdowns of adherence to each individual component of their ERAS pathway. For example, they reported 100% adherence to patient education, nutritional counseling, no prolonged fasting, maintenance of normothermia and using a multimodal approach to analgesia. Meanwhile, Flanders et al. (2020) showed adherence through percentages in some measures, but others simply showed changes from baseline, such as a reduction in Foley use, but not specifically what the adherence was to ensuring this.

Risk of Bias Assessment:

One study was assessed as being of moderate (Debono et al., 2021b) risk of bias, with the rest being assessed at a serious risk of bias (Bradywood et al., 2017; d'Astorg et al., 2020; Debono et al., 2019; Duojun et al., 2021; Flanders et al., 2020; Garg et al., 2021; Heathcote et al., 2019; Kerolus et al., 2021; Li et al., 2018; Li et al., 2021; Smith et al., 2019) (Figure 3.2).

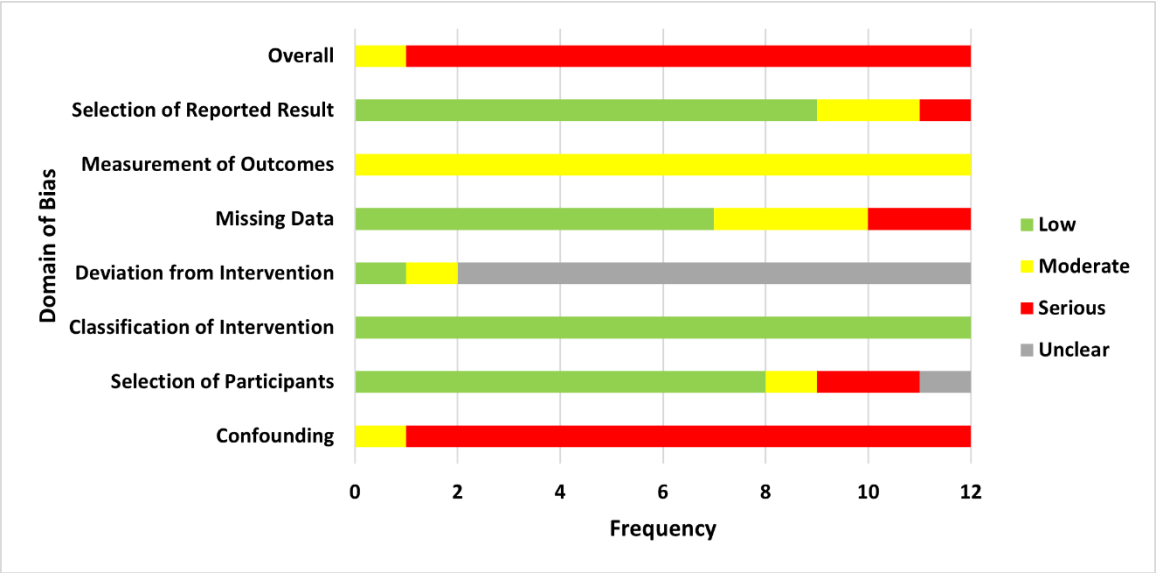


Figure 3.2: ROBINS-I assessment for risk of bias in non-randomized studies.

Due to a lack of fidelity, only two studies (Li et al., 2018; Li et al., 2021) were clear on their adherence to the ERAS intervention, resulting in most studies be listed as 'unable to assess' bias for the deviation from intervention domain, as it was unclear if these ten studies adhered to ERAS fully or not. The primary justification for a judgement of serious risk of bias was due to confounding (Table 3.4), resulting from the studies reflecting an uncontrolled before and after design. Only one study, Debono et al. (2021b), included an approach mitigate the effects of confounding bias through propensity score matching, which has been recommended as an acceptable statistical approach to mitigate bias in non-randomised studies (Lonjon et al., 2014). All studies were clear in their classification of the intervention, and what constituted their ERAS pathway compared to conventional care, resulting in a low risk of bias for that item. All studies were assessed as being a moderate risk of bias in the measurement of outcomes, due to the lack of blinding in the studies included, resulting in bias due to the authors being able to determine which

patients underwent ERAS or not. No studies were identified to have a conflict of interest which were relevant to the study included, which would affect publication bias.

Table 3.4: ROBINS-I assessment for each study based on each domain of bias. A red "X" represents a serious risk of bias, a yellow "- "represents moderate risk of bias, a green "+" represents a low risk of bias and a blue "?" was reserved for when risk of bias was unable to be determined for that domain.

Study	Confounding	Selection of Participants	Classification of Intervention	Deviation from intervention	Missing Data	Measurement of Outcomes	Selection of Reported Result	Overall
Smith et al., 2019[24]	✗	✓	✓	?	✓	!	✓	✗
Li et al., 2018[29]	✗	✓	✓	✓	✓	!	✓	✗
Bradywood et al., 2017[23]	!	✓	✓	?	✗	!	✓	✗
Debono et al., 2021[27]	✗	✓	✓	?	!	!	✓	!
Debono et al., 2019[26]	✗	!	✓	?	!	!	✓	✗
D'Astorg et al., 2020[28]	✗	?	✓	?	!	!	✓	✗
Flanders et al., 2020[21]	✗	✗	✓	?	✗	!	✗	✗
Heathcote et al., 2019[22]	✗	✗	✓	?	✓	!	!	✗
Duojun et al., 2021[30]	✗	✓	✓	?	✓	!	✓	✗
Garg et al., 2021[32]	✗	✓	✓	?	✓	!	✓	✗
Kerolus et al., 2021[25]	✗	✓	✓	?	✓	!	!	✗
Li et al., 2021[31]	✗	✓	✓	!	✓	!	✓	✗

Length of Stay:

Using GRADE, it was assessed that very low-quality evidence showed that ERAS may reduce LoS. Using the GRADE guidelines, we downgraded the quality of evidence from high to moderate, due to the included studies being uncontrolled before and after studies, and then downgraded to low due to the high risk of bias associated with most of the studies. All 12 before-after studies measured LoS; however, the data from one study could not be included as SDs were incalculable. In all cases, LoS was measured in days, except for Smith et al. (2019) who measured it in hours. Thus, for LoS (11 studies; 9062 participants), we found low quality evidence that implementing an ERAS protocol resulted in a statistically significant decrease in LoS by -1.03 (95% CI: -1.36 to -0.70; $p<0.001$; $I^2=93\%$) days (Figure 3.3). Whilst d'Astorg et al. (2020) did not report standard

deviations, a mean change of -1.8 days (4.4 to 2.6) after implementing ERAS was reported in that study. Due to high heterogeneity, we decreased the quality of evidence from low to very low due to inconsistency across studies.

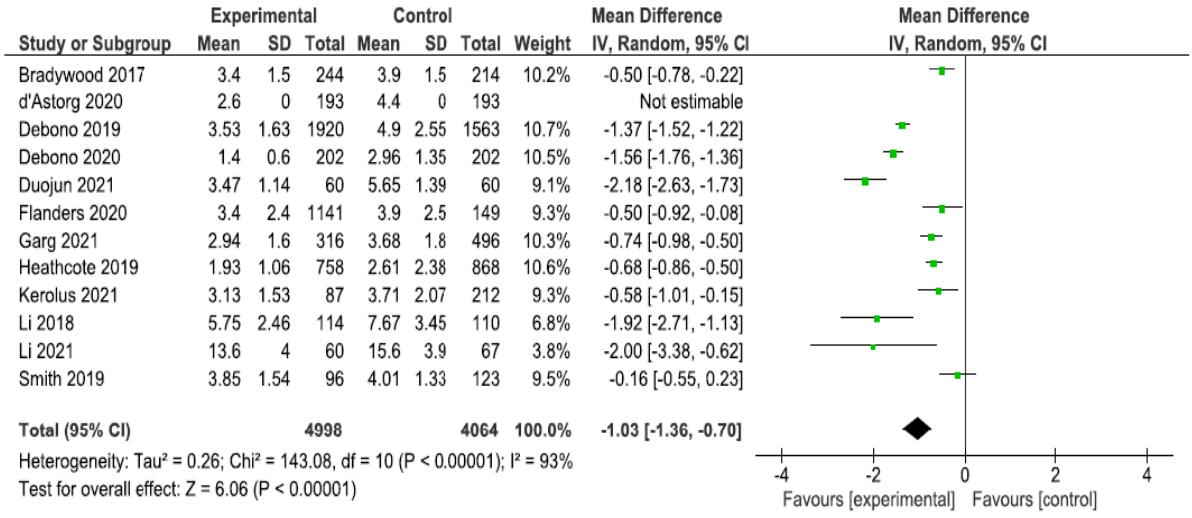


Figure 3.3: A forest plot showing the effect of implementing ERAS protocols for lumbar and cervical spine procedures on LoS.

Re-Admission to Hospital:

Nine of the twelve included studies measured re-admission to hospital with variable assessment timeframes between 30-90 days. One of these studies (Heathcote et al.,2019) did not report their assessment timeframe. We found low quality evidence for no difference between groups receiving ERAS protocols and those receiving usual practices on readmission to hospital at 30 days (6 studies; 3766 participants, Figure 3.4a) OR 0.84 (95% CI: 0.54 to 1.32; p=0.46; I^2=0%), or at 90-days (3 studies; 2055 participants, Figure 3.4c), OR 0.90 (95% CI: 0.52 to 1.55; p=0.70; I^2=0%). Only one study measured re-admission to hospital at 60 days, and also found no significant difference (7/316 re-

admitted for the ERAS group, and 9/496 re-admitted for the control group; p=0.69) (Figure 3.4b). The study with 60-day re-admission to hospital was assessed to have very low quality of evidence due to the low sample size included. Additionally, one study had zero events in both the ERAS and control groups at the 30-days assessment point (Li et al., 2021). As such, no estimate could be performed for that study.

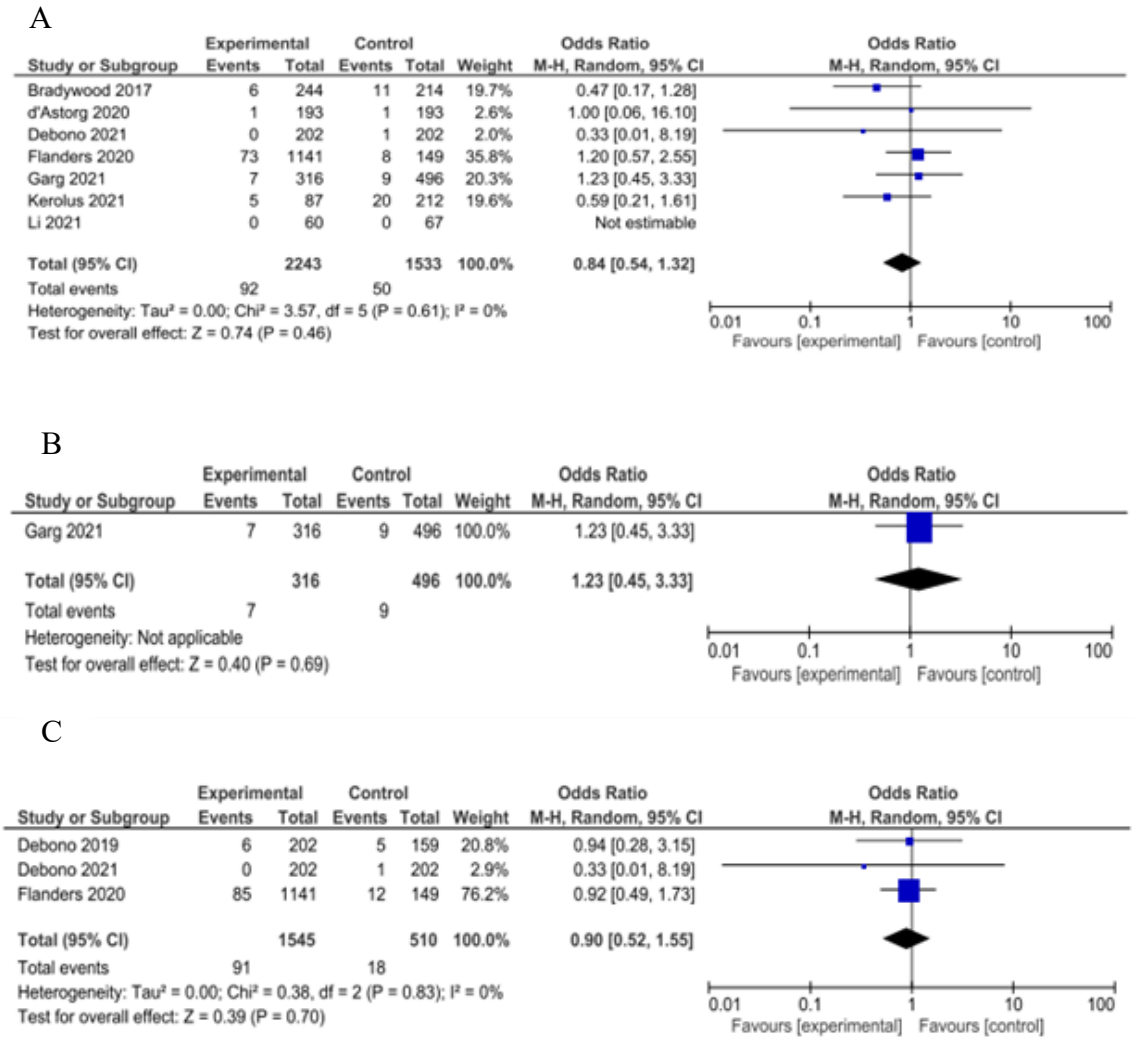


Figure 3.4: Odds ratio for being re-admitted to hospital following spine surgery after 30-days (4a), 60-days (4b) and 90-days (4c) based on being in the ERAS or control group.

Cost Effectiveness:

No studies measured cost effectiveness using the standardized outcome measures of a QALY. However, two studies reported costs pre- and post- the ERAS intervention. Heathcote et al. (2019) reported hospital costs per case as well as service line charges per case prior to and after implementing ERAS, whereas Duojun et al. (2021) only stated that their hospitalizations costs decreased after implementing ERAS but was not statistically significant.

Table 3.5: Summary of findings from the meta-analyses on LoS and re-admission to hospital at 30-, 60- and 90-days following discharge.

Outcome	Pooled Estimate (Mean and 95% CI)	Number of Studies (total sample size across studies)	Level of Certainty (GRADE)
LoS (Days)	-1.03 (-1.36, -0.70)	11 (9062)	Very Low[1, 2, 3]
Outcome	Pooled Estimate (OR and 95% CI)	Number of Studies (total sample size across studies)	Level of Certainty (GRADE)
Re-admission 30-days	0.84 (0.54, 1.32)	6 (3776)	Low[1, 2]
Re-admission 60-days	1.23 (0.45, 3.33)	1 (812)	Very Low[1, 2, 4]
Re-admission 90-days	0.90 (0.52, 1.55)	3 (2055)	Low[1, 2]

Footnote: Based on the GRADE criteria, evidence would start at high quality and be reduced based on the following factors: 1. Study design not being an RCT, 2. RoB being serious or critical, 3. Inconsistency (I^2>75%), 4. Imprecision (the result having less than 2000 people).

Other Outcomes:

Other outcomes were reported infrequently when compared to the primary outcomes of LoS and re-admission to hospital **(**Appendix 3.4). The most frequent other outcome reported were various pain scores (n=9), followed by post-operative complications (n=6), satisfaction (n=5) and then a third (n=4) of the time, functional ability was reported.

Opioid reduction, and re-operation rates were reported a quarter of the time (n=3). Least frequently, cost (n=2), nutrition and urinary retention were measured (n=1).

Discussion:

To our knowledge, this is the first review to examine the effects of an ERAS interventions for reducing LoS after elective spinal surgeries, specifically for degenerative disease. We found very low-quality evidence over 12 studies that ERAS protocols significantly reduced LoS, but demonstrated no effect on re-admission rates, when compared to pre-intervention protocols. In particular we found that implementing ERAS resulted in a decrease of 1.03 (95% CI: -1.36 to -0.70; $p<0.001$) days compared to conventional processes. However, there was significant heterogeneity for the outcome of LoS, which could be due to methodological and clinical heterogeneity amongst the studies.

Findings in relation to other studies

Our finding of a reduced length of stay with implementation of ERAS protocols/strategies are similar to the most recent review of ERAS for elective surgery by Pennington et al (2020) (Appendix 3.2). This review found a similar decrease of 1.22 days (95% CI: -1.98 to -1.47; p=0.002) in a broader range of adult spine conditions including deformity and tumor, and also exhibited a high heterogeneity in their result (I^2=94%). Similar to our review, Pennington et al. (2020) only identified UBA studies and 1 RCT of surgeries for tumor, which reduces our certainty in the estimates of LoS. However, ERAS programs have been evaluated using more rigorous RCTs in other surgery areas such as radical cystectomy (Zhang et al., 2020) and bariatric surgery (Parisi et al., 2020). Systematic reviews of ERAS for these surgery types also indicate a significant decrease in mean

difference for LoS by about -1.12 (95% CI: -1.80 to -0.45; p=0.001; I^2=0%) (Zhang et al., 2020) for radical cystectomy and a mean difference reduction in LoS of -0.51 days (95% CI: -0.92 to -0.10, p=0.001) for bariatric surgery (Parisi et al., 2020).

Rates of re-admission to hospital showed no difference between ERAS and conventional care groups at 30, 60 and 90-days. Whilst ERAS groups did tend to have lower re-admission rates to hospital following surgery, this was not statistically different. Other systematic reviews echo this finding. Elserrag et al. (2019) reported that no included study had a statistically different re-admission rate, as did Dietz et al. (2019) and Tong et al. (2020). Pennington et al. (2020) found that implementing ERAS protocols significantly reduced the 30-day re-admission rate, however they were only able to include three studies for this result (OR=0.37; 95% CI: 0.14 to 0.96; p=0.04). Even though there was no observed difference between ERAS and conventional care groups for our study, a reduction in LoS without compromising re-admission to hospital points to the effectiveness of implementing ERAS and discharging patients sooner, without increasing their risk for complications which require further hospitalization.

Strengths and Weaknesses

Strengths: We adhered to the PRISMA, PRESS, TIDieR, and GRADE guidelines and registered the protocol a priori on open science framework (Appendix 3.3) to allow for a rigorous and transparent assessment of the literature. This review also included a more homogenous population for patients with degenerative spine disease, as opposed to including potentially more debilitating diseases, such as tumor or deformity. Lastly, this study used ROBINS-I as the tool for assessing risk of bias, which is a more

comprehensive tool for measuring bias in non-randomized studies, compared to alternatives such as QUADAS which is for diagnostic tests.

Limitations: The main limitations in this review relate to decisions we made based on resources or stakeholder use. In terms of resources, while we had two reviewers independently screen titles, abstracts and full texts, we only had one reviewer for data extraction and risk of bias which may have resulted in data errors. However, to mitigate this risk, a second reviewer checked outcome data and a sample of the risk of bias assessments for any errors. In terms of analysis, we made the decision to perform a meta-analysis on studies that were non-randomized and of "serious" RoB. The reason for this decision is that uncontrolled before-after studies formed the entire evidence-base for our topic. If there had been randomized studies, we would have limited our meta-analysis to only randomized studies as per best practice. Additionally, we wanted to provide one overall estimate that would be an easier metric for decision makers to interpret. We recognize that the limitation of this decision may be an unreliable pooled estimate of our outcomes. To mitigate this risk, we (i) clearly report the 95% confidence interval around the pooled estimate at all times to ensure the precision of our estimate is clear and (ii) used the GRADE approach to more accurately describe the certainty in the pooled estimate. Additionally, within our GRADE assessment, we used the ROBINS-I as a comprehensive method to assess the risk of bias domain, in particular the risk of bias due to confounding. As such, we believe our GRADE rating of "low" certainty provides an accurate reflection of the pooled estimate.

Studies not available in English represented a limitation for this review, as there were some identified in the full text review as a candidate for the review but excluded. While English is the primary reason for exclusion, if the study were available in English, they also may not have been included due to other study exclusion criteria, such as patient population, so we exclusion due to language alone may not apply to all studies excluded for this reason but would be challenging to know without a translator.

Implications for practice

While we found some evidence that ERAS may be effective at reducing LoS without compromising re-admission to hospital, the quality of evidence is still based on weak study design and could make it difficult to make decisions on implementing it in practice. Moreover, if we only have weak evidence, it may be difficult to convince health providers to implement the ERAS intervention. A major implication we identified is that it is not clear if and how well the different ERAS strategies were implemented, as only two studies actually measured adherence to the ERAS protocol. This is one area that would benefit from having a better understanding of the implementation procedures required to institute ERAS and barriers to their implementation. For example, from the literature, known barriers to implementing ERAS are varied, in that it is a multi-modal approach to care, needing providers from many different specialties to collaboratively contribute to the ERAS pathway, such as surgeons, anesthesiologists, nurses, physiotherapy and nutritionists (Ljungqvist, 2014). Lastly, we found no studies examined cost effectiveness, which, for practice, means we have no way of knowing how much the intervention would cost compared to how much benefit was gained. It is known that some additional costs

could be incurred by implementing ERAS, such as possibly having to pay to develop the new patient education materials, or by having to pay for pre-operative carbohydrate beverages. Without this information, it is challenging to justify the cost of implementing the ERAS intervention without knowing how to budget for the intervention, without also having good quality evidence that the intervention is efficacious as well.

Future research

Research on ERAS and elective spine surgery is still in its infancy. More complex study designs need to be implemented in order to accurately determine the efficacy of ERAS on LoS in the spinal setting. While RCTs are difficult to implement in a surgical setting, it is still possible. If RCTs are not feasible, interrupted time series could be employed, or statistical methodologies such as propensity matching should at least be utilized to improve the quality of the research. Future ERAS studies also need to include more detailed descriptions of the ERAS intervention as compared to previous standard of care. For example, many studies state they included 'improved' patient education, but do not clarify what the improvements are nor measure their effectiveness. Furthermore, future studies need to report adherence to the ERAS intervention. It is difficult at this time to ascertain if ERAS actually does contribute to decreasing LoS, as it is unclear how often ERAS is adhered to once it is implemented. Other outcomes aside from LoS and re-admission should also be considered, such as patient reported outcomes measures and patient satisfaction. Future systematic reviews and meta-analyses should look at performing a meta-regression to determine the impact of potential influencing factors in LoS, such as potential differences between lumbar and cervical spine, or even specific

ERAS components (such as education or narcotic usage). Lastly, future research should also include other outcome measures to evaluate the success of an ERAS program, such as PROMs, patient satisfaction, pain scores, and hospital related outcomes such as complications, opioid consumption, and re-operation rates.

Conclusion

Currently, studies which examine the efficacy of ERAS programs on reducing LoS for elective spine procedures have consistently shown an improvement in hospital stay following surgery, without compromising re-admission to hospital. However, there is a very low level of evidence for this estimate, as existing research for spine and ERAS has been subject to high risk of bias when compared to other surgical fields which were able to implement ERAS and use randomized control trials. Future research would benefit from more rigorous studies implementing randomized control trials, or by controlling confounding factors with more sophisticated statistics such as propensity matching.

Chapter 4 : What Barriers Prevent Patients from being Discharged from Hospital Following Elective Spine Surgery: A Prospective Cohort Study

Ryan Greene[1, 2], Amanda Hall[3], Holly Etchegary[1], and Sean Christie[2]

1. Faculty of Medicine, Memorial University of Newfoundland, St. John's, NL

2. Department of Surgery (Neurosurgery), Dalhousie University, Halifax, NS

3. Primary Health Research Unit, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada

Co-authorship Statement

As primary author, I helped develop the study design, collected all the data, submitted and obtained ethics approval, abstracted the data, interpreted the results and wrote the manuscript. Dr. Hall provided assistance with the study design, interpreting the results, reviewed and helped develop the manuscript. Dr. Etchegary helped with interpreting the results and with reviewing the manuscript. Dr. Christie assisted with study design, interpreting the results and with reviewing the manuscript.

Introduction:

Length of stay (LoS) after surgery is problematic for healthcare systems and patients alike. For healthcare systems, LoS represents a significant financial burden (Mathew et al., 2018), with the cost of the hospital stay sometimes outweighing the cost of the procedure. Current LoS for spine surgery varies from hours (Soffin et al., 2019) to several days (Blackburn et al., 2016), with an average of four days being reported in the United States (Goz et al., 2013). For patients, each day in hospital can be associated with a 5% increase in odds of a complication such as urinary tract infection (UTI) or pneumonia (Mathew et al., 2018). Furthermore, patients who are discharged from hospital sooner report increased satisfaction with their procedure (Bradywood et al., 2017).

Enhanced Recovery After Surgery (ERAS) interventions are pathways designed to improve patients' recovery after surgery. Evidence from randomized controlled trials (RCTs) of ERAS interventions in fields such as colorectal, pelvic, hip/knee, and gynecologic/oncology surgery have shown improvements on length of stay (LoS), patient satisfaction, and costs to the healthcare system (Parisi et al., 2020; Zhang et al., 2020). Less is known about the effectiveness of ERAS interventions for spinal surgery.

Identifying what factors prevent patients from being discharged from hospital can help facilitate the efficient use of limited hospital resources. While few studies have focused on barriers to discharge, Husted et al. (2011) observed that in the first two days after fast-track hip and knee arthroplasty, pain, dizziness, and general weakness were the most commonly reported reasons for a patient remaining in the hospital (Husted et al., 2011). To a lesser extent, nausea, vomiting, and confusion also contributed to delay of discharge

(Husted et al., 2011). Following the first two days of patients' stay, they reported that waiting for a blood transfusion, waiting to start physiotherapy, or the need for diagnostic imaging delayed discharge in 1 out of 5 of patients (Husted et al., 2011). In other procedures, it seems that time of surgery is important. Gale et al. (2018) observed that patients who were the first operation of the day had a 91.2% same day discharge rate, whereas those who had surgery after the first surgery of the day, had a 64.7% same day discharge rate. Similarly, literature on laparoscopic sleeve gastrectomy procedures also observed that operations performed earlier in the day reduced time to discharge (Jonnson et al., 2018). Anecdotally, at our site, spine surgery clinicians have indicated that patients often think they must remain in hospital to have their pain managed and will not be discharged until they are pain free which can sometimes complicate discharge procedures.

Objectives

This study sought to:

1. Identify the hospital-based reasons patients were not discharged after a one-night hospital stay following their scheduled spine surgery at the QEII.
2. Understand why patients believe they were not discharged after a one-night hospital stay in order to determine if there is a knowledge gap between the reasons patients believe they remain in hospital compared to the hospital's reasons for continued stay.

To achieve these objectives, we conducted this project in two parts: a prospective clinical audit to assess hospital-based reasons for non-discharge and a descriptive cohort study to describe patient-reported reasons for the same.

Methods:

Ethics: Ethics approval for this study was obtained from the Nova Scotia Health Research Ethics Board, file number 1026525 (Appendix 4.1).

Protocol registration: The protocol for this study was uploaded to open science framework (Appendix 4.2).

Setting: Both the clinical audit and descriptive cohort study were carried out at a single hospital center (the QEII in Nova Scotia). This site offers surgeries for a broad range of conditions Monday-Friday from 8:00am-5:00pm. The QEII is a publicly funded hospital (including the Halifax Infirmary and the Victoria General Hospital) which serves all patients who require spine surgery in both Nova Scotia and Prince Edward Island, and has a total of six spine surgeons. After surgery and recovery from anesthesia, patients are moved to the dedicated inpatient spine floor which has one charge nurse and multiple registered nurses.

Part 1: Prospective clinical audit

Study Design:

This was a prospective clinical audit that assessed hospital-based reasons patients were not discharged following a one-night hospital stay for patients who received elective spine surgery for a degenerative condition of the spine within an 8-month period. This

protocol was developed according to the Standards for Reporting for Observational Studies (STROBE) guidelines. A copy of the completed STROBE Checklist can be found in Appendix 4.3.

Participants:

Patients were included in the study if they were aged 18 or older and had received elective posterior cervical or degenerative lumbar fusion surgical procedures during the study period. Degenerative conditions for which these procedures are indicated include lumbar stenosis, spondylolisthesis, disc herniation or cervical myelopathy.

Exclusion criteria: Patients were excluded if they were under the age of 18 and/or had received any urgent/emergent, same-day, infection or cancer-related, or lumbar fusion for deformity spine procedure.

Sample and study period: Charts for all patients meeting the inclusion criteria during an 8-month period (April 1-November 30, 2021) formed the population for this audit. Patients from this population who were identified to have a hospital stay greater than one night formed the study sample.

Data collection procedures: Data was collected twice per day during the study period; researcher (RG) met with the charge nurse at 10:00am and 3pm daily until the patient was discharged to determine if the patient would be going home that day and, if not, what barrier(s) was preventing their discharge.

Data collection variables:

<u>Patient characteristics</u>

At baseline, we abstracted patient age, sex, body mass index (BMI), American Society of Anesthesiologists (ASA) grade (subjective assessment of the patients' overall health (Daabiss, 2011)), recorded discharge destination (home, home hospital, or rehab center), specialty of the surgeon (orthopaedics or neurosurgery), surgical site (cervical or lumbar), and procedure performed (decompression alone or a decompression and fusion) from patient charts (Appendix 4.4).

Length of stay (LoS)

Length of stay data was collected from the charge nurse; it was defined in days and measured as the number of nights a patient stayed in hospital until discharged.

Reasons for prolonged stay

Data on reasons for prolonged stay were collected using a standardised data extraction form (see Appendix 4.5). A list of potential reasons for prolonged stay was presented to the nurse on duty. These included: poor pain management, dizziness, confusion, sedation, post-op nausea and/or vomiting, urinary retention, muscle weakness, technical reasons, and logistic reasons. There was also an option to select "other" with space provided to describe why the patient needed to remain in hospital. Selection of up to two reasons per patient were solicited.

Analysis:

Continuous data are reported as means (and standard deviations) or medians (and interquartile range), with categorical variables described as frequencies and percentages. Hospital reasons for prolonged stay are reported as frequencies (as well as relative

percentages of all reasons reported). For the hospital- and patient-reported reasons for prolonged stay, the data are described for each data collection period (10:00am and 3:00pm each day the patient remained in hospital). Due to patients possibly having more than one factor preventing their discharge, the frequency of responses and the percentage may exceed the sample size of patients for that day and time of the interview. All analyses were performed using SPSS Statistics Version 28 (IBM, Armonk, NY, USA).

Part 2: Descriptive cohort study

Study design: A descriptive cohort study was used to determine patients' understanding of why they were not discharged from hospital after their first night's stay.

Recruitment and consent: All participants (n=47) included in the sample for the clinical audit were approached by a researcher (RG) and asked if they would be interested in taking part in the "Patient Reasons for Prolonged Stay Study." Interested patients were provided with an informed consent form describing the study, expectations of participation, and risks and benefits associated with their participation.

Data collection procedures: For participants who agreed to take part in the study, a researcher (RG) met with them twice daily (during the same times as the hospital-based reasons audit, i.e., 10am and 3pm) until they were discharged from hospital to assess their understanding of what was preventing their discharge.

Data collection variables:

<u>Demographic variables</u>

These included smoking status, height, weight, education level, marital status, living arrangement and the first three alphanumeric digits of their postal code.

Patient-reported reasons for prolonged stay

The same list of potential reasons for prolonged stay used to assess hospital-based reasons for prolonged stay was presented to the patient. This list included: poor pain management, dizziness, confusion, sedation, post-op nausea and/or vomiting, urinary retention, muscle weakness, technical reasons, and logistic reasons. There was also an option to select "other" with space provided to describe why the patient needed to remain in hospital. While there were no descriptions provided describing each of the main reasons from which participants could select, the researcher did provide a generic description for patients and answered any questions.

Sample: A sample of convenience was used.

Analysis: Continuous variables are described with means and standard deviations, with categorical variables described using frequencies and percentages.

Patient-provided reasons for prolonged stay are reported as frequencies (as well as relative percentages of all reasons reported). For the patient reported reasons for prolonged stay, the data is described for each data collection period 10:00am and 3:00pm each day the patient remained in hospital). Due to patients possibly having more than one factor preventing their discharge, the frequency of responses and the percentage may exceed the sample size of patients for that day and time of the interview. All analyses were performed using SPSS Statistics Version 28 (IBM, Armonk, NY, USA).

Results:

Participants:

Data from 102 patient charts were assessed during the study period. Of these, 55 patients were discharged after a 1-night stay and had no barriers to discharge (Appendix 4.6). Among the remaining 47 patients with barriers that prevented discharge, 38 patients consented to be interviewed as to why they believed they remained in hospital. Please see Table 4.1 for a description of the demographic and clinical characteristics of the audit sample that were abstracted from patient charts (n=47).

Table 4.1: Demographic and clinical characteristics of the audit sample collected at baseline.

Patient characteristics	Sample with prolonged stay (n=47)
Age (mean, SD)	62.57±12.20
Sex (%female)	23 (48.9%)
BMI	30.09±7.29
ASA Grade 1	2 (4.26%)
ASA Grade 2	29 (61.70%)
ASA Grade 3	16 (34.04%)
Discharge destination	
• Home	36 (76.60%)
• Home Hospital	6 (12.77%)
• Rehab Center	5 (10.63%)
Surgical site	
• cervical	17 (36.17%)
• lumbar	30 (63.83%)
Surgery Type	
• Decompression Alone	22 (46.81%)
• Decompression and Fusion	25 (53.19%)
Surgeon Specialty	
• Neurosurgeon	21 (44.68%)
• Orthopaedic surgeon	26 (55.32%)

Descriptive Data:

The average age of the clinical audit sample was 62.57 (±12.20) years old, with 23 (48.9%) patients being female (Table 4.1). Most patients' recorded discharge destination was home (n=36, 76.60%), with the rest recorded as home hospital (n=6, 12.77%) or a rehab center (n=5, 10.63%). Neurosurgeons performed 21 (44.68%) of the operations; orthopaedic surgeons performed 26 (55.32%). A decompression alone was offered to 22 (46.81%) patients; the rest received a decompression and fusion. Thirty (63.83%) patients had surgery on their lumbar spine while 17 (36.17%) received surgery on their cervical spine. Average LoS for the cohort was 4.66 days (±4.49), with a median stay of 3 days. Total range for LoS was 2-26 days. Ten days post-surgery, only three patients remained in hospital. Only one patient who had an infection remained in hospital beyond 15 days.

Reasons for discharge

Reasons for discharge were collected at two time points for each day following spine surgery. At each time point, up to two reasons were provided for prolonged hospital stay. Thus, the number of reasons provided is higher than the total number of patients for each measurement point. We present the data for all time points in both a table (Table 4.2) and a figure format (Figure 4.1) to help identify patterns in the data. For the patient-reported data, the number of patients and reasons for prolonged stay provided are lower than the hospital-based reasons. Fewer patients consented to participate (n=38) than charts available (n=47) for the audit.

1. *Hospital-based barriers to discharge:*

Please see Table 4.2 and Figure 4.1 for the complete list of hospital-based barriers to discharge during our study. For the first five days following surgery, mobilization was the most commonly reported hospital-based barrier to discharge. On days one to three, urinary retention was the second most common reason reported. Starting on day four, however, logistic reasons were more commonly cited. After this time point, the number of patients and reasons precludes us from determining meaningful patterns in the data. Hospital staff listed the following barriers to discharge in the "other" category: Hemovac, best rest, patient fear of going home, patient confrontational about leaving, stool issues, hypotension, infection, oxygen concerns, anxiety. No reason listed in the "other" category was a frequently reported barrier to discharge.

2. *Patient-reported barriers to discharge:*

For patients, poor pain management was the most commonly reported factor believed to be preventing discharge from hospital in the first 3 days following surgery (Table 4.2 and Figure 4.2). For days 1-3, mobility was the second most common reason selected by patients for their continued hospital stay. After day three, the number of patients and reasons precludes us from determining meaningful patterns in the data. Patients listed the following as "other" barriers to discharge: stool issues, surgeon is keeping them in hospital against their will, doesn't have the willpower to go home, not healthy enough overall for discharge, ordered bed rest, monitoring a potential CSF leak, weening off painkillers, fear of going home, refusal to leave hospital, drainage of incision site, oxygen concern. No reason listed in the "other" category was a frequently reported reason at any timepoint.

Descriptive comparison of hospital and patient-reported reasons for prolonged stay:

There were clear differences between why patients believed they could not be discharged and reasons reported by hospital staff. Interestingly, while patients did note the important role of mobility in their ability to be discharged, as this was the second most common barrier to discharge, they selected poor pain management as the most common reason for their continued hospital stay. This represents the largest discrepancy between patients' and hospital staff understanding of barriers to discharge.

Table 4.2: Hospital selections from a list of provided reasons for prolonged hospital stay.

		Hospital Reasons										
		Patient (n)	Reasons (n)	**Pain Mgmt**	**Nausea/vomiting**	**Urinary retention**	**Muscle weakness**	**Technical reasons**	**Logistic reasons**	**Mobility**	**Dizziness**	**Confusion**
Day 1	AM	47	**61**	8	2	19	3	0	2	27	0	0
	PM	47	**59**	8	2	18	2	0	2	27	0	0
Day 2	AM	29	**39**	7	0	11	0	1	4	16	0	0
	PM	29	**38**	7	0	11	0	1	4	15	0	0
Day 3	AM	19	**23**	4	0	5	1	0	4	9	0	0
	PM	19	**20**	1	0	5	1	0	4	9	0	0
Day 4	AM	13	**16**	3	0	2	1	0	4	6	0	0
	PM	13	**15**	3	0	2	1	0	4	5	0	0
Day 5	AM	12	**14**	2	0	1	2	0	4	5	0	0
	PM	12	**19**	2	1	2	0	4	5	5	0	0
Day 6	AM	9	9	0	0	1	1	0	4	3	0	0
	PM	9	9	0	0	1	1	0	4	3	0	0
Day 7	AM	7	9	2	0	1	2	0	3	1	0	0
	PM	7	9	2	0	1	2	0	3	1	0	0
Day 8	AM	6	9	2	0	1	2	0	3	1	0	0
	PM	6	9	2	0	1	2	0	3	1	0	0
Day 9	AM	5	5	1	0	0	1	0	2	1	0	0
	PM	5	5	1	0	0	1	0	2	1	0	0
Day 10	AM	4	4	1	0	0	1	0	1	1	0	0
	PM	4	4	1	0	0	1	0	1	1	0	0
Day 11	AM	3	3	1	0	0	1	0	0	1	0	0
	PM	3	3	1	0	0	1	0	0	1	0	0
Day 12	AM	3	3	1	0	0	1	0	0	1	0	0
	PM	3	3	1	0	0	1	0	0	1	0	0
	AM	3	4	1	0	1	1	0	0	1	0	0

Day 13	PM	3	3	0	0	1	0	0	1	1	0	0
Day 14	AM	2	2	0	0	1	0	0	0	1	0	0
	PM	2	2	0	0	1	0	0	0	1	0	0
Day 15	AM	1	0	0	0	0	0	0	0	0	0	0
	PM	1	0	0	0	0	0	0	0	0	0	0

Notes:
- When asked, nurses listed the following reasons in the other category: Hemovac, best rest, patient fear of going home, patient confrontational about leaving, stool issues, hypotension, infection, oxygen concerns, anxiety. No reason listed in the other category was a frequently reported reason at any timepoint.
- Sedation, dizziness, or confusions were not selected as a barrier for discharge by hospital staff at any timepoint.

Table 4.3: Patient selections from a list of provided reasons for prolonged hospital stay.

		Patient Reasons										
		Patient (n)	Reasons (n)	**Pain Mgmt**	**Nausea/vomiting**	**Urinary retention**	**Muscle weakness**	**Technical reasons**	**Logistic reasons**	**Mobility**	**Dizziness**	**Confusion**
Day 1	AM	38	**40**	14	2	8	3	1	1	10	1	0
	PM	38	**42**	17	3	7	2	1	1	10	1	0
Day 2	AM	23	**28**	10	1	2	2	0	4	9	0	0
	PM	23	**31**	11	2	2	2	0	4	10	0	0
Day 3	AM	15	**23**	8	1	2	3	0	3	5	0	1
	PM	15	**23**	8	1	2	3	0	3	5	0	1
Day 4	AM	10	**12**	4	1	0	2	0	3	2	0	0
	PM	10	**15**	4	1	0	5	0	3	2	0	0
Day 5	AM	10	**10**	3	1	0	2	0	3	1	0	0
	PM	10	**10**	3	1	0	2	0	3	1	0	0
Day 6	AM	7	6	1	0	0	1	0	3	1	0	0
	PM	7	6	1	0	0	1	0	3	1	0	0
Day 7	AM	5	6	1	0	0	2	0	2	1	0	0
	PM	5	6	1	0	0	2	0	2	1	0	0
Day 8	AM	4	4	1	0	0	1	0	2	0	0	0
	PM	4	4	1	0	0	1	0	2	0	0	0
Day 9	AM	4	4	1	0	0	1	0	2	0	0	0
	PM	4	4	1	0	0	1	0	2	0	0	0
Day 10	AM	3	3	1	0	0	1	0	1	0	0	0
	PM	3	3	1	0	0	1	0	1	0	0	0
Day 11	AM	2	2	1	0	0	1	0	0	0	0	0
	PM	2	2	1	0	0	1	0	0	0	0	0
Day 12	AM	2	2	1	0	0	1	0	0	0	0	0
	PM	2	2	1	0	0	1	0	0	0	0	0
Day 13	AM	2	2	1	0	0	1	0	0	0	0	0
	PM	2	1	0	0	0	0	0	1	0	0	0
Day 14	AM	1	0	0	0	0	0	0	0	0	0	0
	PM	1	0	0	0	0	0	0	0	0	0	0
Day 15	AM	0	0	0	0	0	0	0	0	0	0	0
	PM	0	0	0	0	0	0	0	0	0	0	0

Notes:
- When asked, patients listed the following reasons in the other category: stool issues, surgeon is keeping them in hospital against their will, doesn't have the willpower to go home, not healthy enough overall for discharge, ordered bed rest, monitoring a potential CSF leak, weening off painkillers, fear of going home, refusal to leave hospital, drainage of incision site, oxygen concern. No reason listed in the other category was a frequently reported reason at any timepoint. Sedation was not selected as a barrier to discharge by patients at any timepoint.

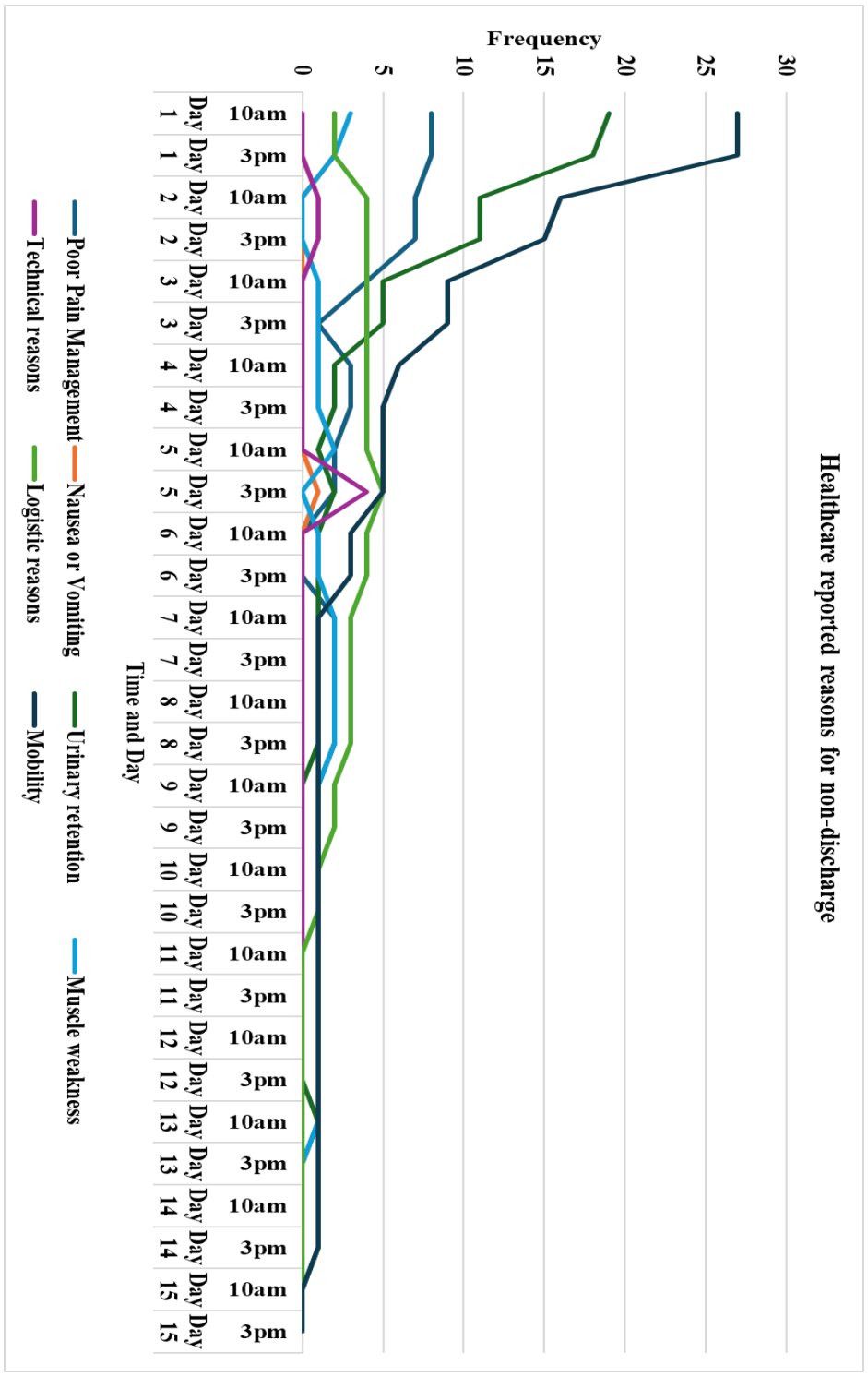


Figure 4.1: The frequency of six hospital-based reasons for non-discharge in the fifteen days following surgery.

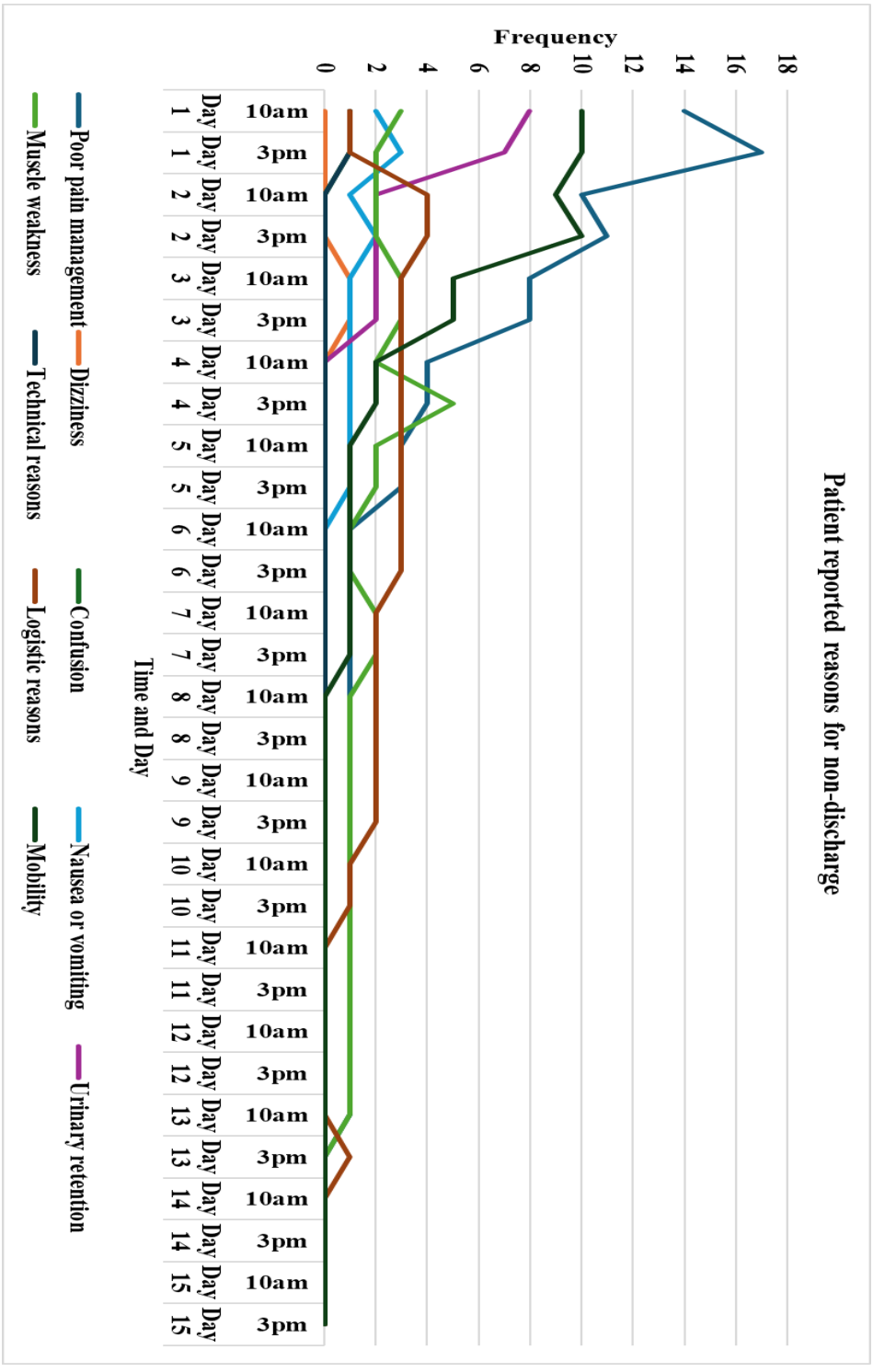


Figure 4.2: The frequency of patient-selected reasons for non-discharge in the fifteen days following surgery.

Discussion:

Summary of Findings:

This is the first study to assess hospital-based reasons for delayed discharge following spine surgery. In addition, it is the first study of which we are aware to assess patient-reported reasons for delayed discharge for any type of surgery. Over our eight-month study period, about half of the patients who underwent spine surgery required an extended LOS (beyond one-night). Within the first 5-days of a patient's stay, issues surrounding mobility were the most common hospital-based reasons for prolonged stay followed by urinary retention on days one-three post-surgery. Issues surrounding logistics (such as trying to discharge a patient to a different hospital or rehab) took up a greater percentage of the reasons for non discharge in LoS after the third overnight stay in hospital. Patients had different opinions on why they remained in hospital. Patients expressed issues surrounding pain management as the most frequent contributor as to why they remained in hospital. Compared to nursing staff, they also underreported urinary retention. Patients did, however, recognize that mobilization was an important component to their recovery, and also frequently reported that their lack of mobilization was a factor contributing to their discharge.

Comparison to the Literature:

As noted, we are not aware of any reported literature which discusses patient reported reasons for non-discharge. This section will discuss hospital-based reasons for non discharge. Golubovsky et al. (2018) reported that patients who undergo elective lumbar spine surgery for stenosis and experienced post-op urinary residuals (POUR), were more

likely to also require discharge to a skilled nursing facility and had an increased risk of re-admission to hospital. They also reported that 17.1% of patients developed issues with urinary retention; our study observed a similar number of patients with urinary retention at 18.63% (n=19) on post-op day 1.

Husted et al. (2011) also examined what factors prevented discharge following total hip and knee arthroplasty. In their study, pain, dizziness, and weakness were the main reason for non-discharge at 24 hours whereas nausea, vomiting, confusion, and sedation were the most common reasons for non-discharge at 48 hours. In the literature, it has been observed that for every 50ft a patient is able to ambulate, the odds of longer LoS decreases by 39% (Macki et al., 2020). In our study, urinary retention was the second-most common hospital-based reason for non-discharge, whereas Husted et al. (2011) found that while urinary retention was a factor preventing discharge, it was only problematic for patients within the first 24-hours.

Husted et al also observed the post-operative need to start physiotherapy and post-operative imaging delayed discharge for one in five patients (Husted et al., 2011). This factor was not assessed in our study.

Other spine research has also looked at issues surrounding post-operative urinary tract infections, and how UTIs impact short term outcomes (Di Capua et al.,2017). In our study, we also didn't ask about this issue specifically, so we are unable to determine if this issue contributes to delayed discharge at our site.

Implications for Research:

This study observed a number of reasons for delayed discharge in the first few days following spine surgery. Future research could be directed at developing a multi-component intervention to target each of these issues simultaneously. In doing so, we may need to further explore the root causes of identified barriers to discharge. For example, urinary retention was one of the most common barriers to delayed discharge. However, bladder function can be affected by more than just the use of catheters (e.g., medication) and so more than one type of strategy would likely need to be developed to address urinary retention.

This study observed that patients reported pain management to be the most common reason for their prolonged hospital stay, but this was not the most commonly reported reason reported by the healthcare team. This discordance indicates that patients and healthcare teams may have different priorities during the patient's recovery. To address this, future studies can research how to improve patient education in this cohort in order to set realistic expectations regarding pain management. Our results suggest anticipatory guidance on what a normal or expected amount of pain is associated with the procedure and during recovery could be useful. However, we suggest guidance/education be co-designed with patients having lived experience of spinal surgery to ensure optimal understanding of the patient pain experience and to guide patient-centered education and intervention development.

Implications for Practice:

This research has shown that mobilization, urinary retention, and logistical factors (e.g., problems transferring patients to home hospital or rehab centres) are common barriers to

discharge in this cohort. While addressing each of these may be effective for reducing LoS, the strategies would likely be challenging for health systems to support. This is largely a result of financial constraints as addressing these issues may be costly with respect to requirements for additional staff, equipment, and/or space. Having a more considered discussion with stakeholders to assess feasibility and costs and benefits associated with the strategies is required.

Further, the discord between patient expectations regarding pain management has an implication for how patient education is delivered prior to surgery. Patient education content and delivery methods may need to be adjusted so that patients have a better understanding of the criteria for discharge, particularly when it comes to pain management post-surgery.

Strengths and Limitations:

This was a prospective cohort study, which allowed us to mitigate issues associated with retrospective studies, such as recall bias. By reviewing hospital-based reasons for non-discharge with the charge nurse (as opposed to simply reviewing patients' charts), we were able to ascertain more accurate information than from a simple chart review which may have required us to make assumptions about the information provided.

This study is limited by the fact that we collected only two factors preventing discharge (the primary and secondary reasons) as opposed to allowing more options to be selected. The results may also be limited by the study sample collected during the study period. Historical data indicated that we could have reasonably expected 200 spine surgery

patients during this period. However, we were only able to include 102 patients as Covid-19 lock-downs reduced our site's capacity to perform elective spine procedures. Furthermore, during this time period, patients who were offered surgery were likely to have less complex surgery, as there was an effort to avoid keeping patients in hospital for prolonged periods of time if possible. All of this reduces the reliability of our findings. However, this research still provides novel information surrounding what factors keep patients in hospital, specifically related to discharge standards that patients need to meet in order to go home.

Conclusion:

Identifying the most common factors preventing discharge from hospital following elective spine surgery is the first step in developing targeted and efficient interventions to reduce LoS. In this study, we found that post-operative issues related to poor mobility and urinary retention were the most common reasons preventing discharge. By addressing these two common issues, through earlier mobilization and monitoring of baseline post-void residuals, we could potentially reduce LoS for these patients. Future studies should consider targeting these factors post-operatively, such as by implementing early mobilization, or by monitoring urinary retention pre-operatively, to determine if LoS can be reduced. Future research should also examine post-operative adherence to strategies aimed at helping the patient achieve discharge efficiently. For example, while mobilization was a key factor identified that patients struggled with to be discharged from hospital, there was no discrepancy between the patient having mobilization issues due to their medical condition, or if their mobilization issues were related to not having staff

mobilize the patient. Future research should also consider the role of patient education in regard to patient understanding for what their post-operative recovery may look like. Lastly, future studies could focus on improved patient education, specifically regarding their pain management post-operatively. With the increasing uptake of ERAS protocols for spine surgery, identifying factors which influence LoS should be considered an important component of implementing these programs.

Chapter 5 : Development of Improved Patient Educational Material for Elective Spine Surgery: A Patient Engagement Initiative

Ryan Greene[1, 2], Amanda Hall[3], Sean D Christie[2], and Holly Etchegary[1]

1. Faculty of Medicine, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada

2. Department of Surgery (Neurosurgery), Dalhousie University, Halifax, Nova Scotia, Canada

3. Primary Health Research Unit, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada

Co-authorship Statement

Ryan Greene designed the study, developed materials to describe the study aim to potential patient partners, facilitated patient engagement discussion groups, recorded transcripts of the meeting and abstracted and interpreted the data. Ryan also wrote the manuscript. Dr. Hall helped design the study, interpret the results, and reviewed the manuscript. Dr. Christie helped interpret the results and reviewed the manuscript. Dr. Etchegary helped design the study, recruited patient partners, attended stakeholder discussions, recorded transcripts from the meetings, interpreted the results and reviewed the manuscript.

Introduction:

Patient education is an important component of offering a patient surgery. In enhanced recovery after surgery (ERAS) protocols, patient education is a core pillar of pathways delivered (Ljungqvist, 2014). Effective education is important as it is necessary for managing expectations of the patient regarding their surgery (Debono et al., 2021a). For example, Burgess et al. (2019) found that patients with improved pre-operative education experienced corresponding improvements in post-operative mobility and reduced anxiety and pain scores. Patients who are uncertain regarding their outcomes can develop increased anxiety and fear, negatively impacting their recovery (Burgess et al., 2019). In recent years, education has shifted from simply explaining the procedure to the patient to engaging the patient as an active participant in their own care (Graffigna et al., 2018). It is also suggested that education should be offered to both the patient and their caretaker (Lee et al., 2018).

Across healthcare contexts and health research, it is now well-accepted that patient engagement improves healthcare delivery, research, and health outcomes (Bombard et al., 2018; Forsythe et al., 2018). Leading funders and journals now regularly call for patient engagement in research and healthcare improvement projects (e.g., Canadian Institutes of Health Research, 2014; Forsythe et al., 2016; Richards, 2017). In Canada, the Strategy for Patient Oriented Research (SPOR) sets out a vision for patient engagement where individuals with lived experience of a health issue, including their families and caregivers, are engaged in ‘meaningful and active collaboration’ with researchers,

clinicians and other stakeholders to 'improve healthcare system and practices' (Canadian Institutes of Health Research, 2014).

At the QEII, the Spine Program has been considering adopting ERAS. Currently, patient education is offered during a face-to-face meeting with the surgeon and supplemented with a 30-page patient education booklet. As part of developing an ERAS intervention, stakeholders at the QEII are aware that their existing methods for patient education will also require updating. While developing a new patient education material is beyond the scope of this thesis, we wanted to take an initial step towards engaging with patients regarding their perspectives on delivery methods for education. We will provide this information to the QEII to help inform their development of any new patient education strategy within their ERAS intervention.

The objective of this patient engagement initiative was to discuss with patients how they engage with educational material and their preferences for mode of education delivery. Engaging with individuals with lived experience of surgery and having previously received surgical education will directly inform the development of educational content and mode of delivery in our education ERAS intervention.

Methods:

Ethics review was not required for this patient engagement exercise. However, we followed ethical principles from the Tri-Council Policy Statement 2 (TCPS2) program and adhered to the principals for designing and reporting qualitative approaches to data collection. As such, to ensure transparency of our approach and fulsome reporting, we have used two reporting guidelines:

1. The Guidance for Reporting Involvement of Patients and Public (GRIPP2) short form (Staniszewska et al., 2017) (Appendix 5.1) to ensure we reported all aspects relevant to patient and public involvement.

2. The Standards for Reporting Qualitative Research (SRQR) (Appendix 5.2) as a framework for describing our qualitative approach for information collection and use.

Information Collection and Use

We engaged with patients to inform the planning and design of a new education intervention for patients undergoing spine surgery. Our patient engagement initiative was qualitative in nature using a semi-structured question guide during discussion groups. Discussion groups were used instead of focus groups in order to draw on local patient experiences specifically to inform decision-making regarding the development of a patient education intervention that we could test in a future trial (Doria et al., 2018). This approach was preferred as the focus is on the patient(s) being an active contributor to the group and research team, as opposed to being a research participant who answers research questions (Doria et al., 2018).

Context for patient engagement

As described in our introduction, we wanted to provide initial feedback on patient perspectives for different delivery methods for education. To undertake this engagement activity, we followed the International Association for Public Participation (IAP2) framework, where we considered the engagement activity to be at the level of consult. This goal of the consult level is to gain feedback on a topic and synthesize the feedback in

a way that indicates how patient input can be used in the design of a study. In the context of our engagement activity, our consult goal is to gain patient feedback on different delivery methods that could be used to deliver patient education at the QEII, synthesize the findings and provide a summary of the feedback to stakeholders at the QEII Spine Program and administration.

The delivery of patient education is not a one size fits all approach. There is considerable heterogeneity in patient learning styles and education preferences. Further, with limited healthcare resources (e.g., financial or availability of healthcare staff and facilities required to provide education), it is imperative to deliver education which is accessible to as many patients as possible. It is beneficial to understand the educational preferences and experiences of patients who have already undergone spine surgery, both content and mode of delivery. We aimed to draw on past patient experiences to inform how best to revise and update an educational program for current spinal surgery patients. Our team was limited to four different potential educational tools due to constraints of what our facility could realistically offer given the cost of the educational resources and space and healthcare staff available to provide the education. As well as exploring unique patient experiences and preferences during engagement sessions, these choices were presented and discussed during the sessions.

Patient Partner Recruitment

The patient engagement opportunity was advertised widely through regular channels of the provincial SPOR SUPPORT Units. A co-author (HE), who is the patient engagement lead for the patient advisory panel in Newfoundland used her connections nationally with

patient-oriented research units to recruit potentially interested patient partners to engage with this discussion group. Interested patient partners contacted RG directly who arranged discussions to further explain the patient engagement activity and answer any questions. The engagement invitation is provided in Appendix 5.3. Patient with lived experience of any surgical procedure were eligible in an attempt to capture a diverse background of patients with surgical education experience. A PowerPoint presentation was provided to all participants before the discussion group that detailed information on ERAS, and what would be discussed during the meeting (Appendix 5.4).

Information Collection

As this study was conducted during the Covid-19 pandemic, all meeting sessions were attended virtually via Zoom. Patients were invited to attend one of two discussion group times. If someone could not attend the discussion groups, arrangements were made for a one-to-one virtual meeting. Key discussion points were transcribed via pen and paper or Microsoft Office Word during the engagement sessions by two researchers (RG and HE) who compared notes following the sessions to ensure accuracy. Questions pertained to (i) prior pre-surgical education experiences (e.g., delivery and content) as well as (ii) patient preferences for how education could be delivered in the future and (iii) feedback (barriers and enablers) on four potential delivery methods:

1. A nursing phoneline that patients could call during specific hours in the lead-up to their surgery.
2. A video brochure that included a screen with pre-recorded videos which would be given to the patient once offered surgery.

3. Online videos which would be developed by healthcare staff at our facility to ensure patients received site-specific information regarding what to expect for their procedure.
4. In-person, classroom-style sessions which would be offered by a member of the healthcare team at the hospital to patients and their caregiver(s).

A PowerPoint presentation was prepared for the start of the discussion sessions and delivered by an author (RG) to discuss the rationale and topics which would be covered in the engagement session (the presentation is attached in the appendix 5.3). Each discussion group began with an informal introduction, starting with the researchers (RG and HE), and then moved to each participating patient, where they would tell us about who they were, where they are from, and their experience with medical education in the past. The questions that guided the discussion group were:

1. How can we get patients to be an active part of their own recovery and how do we engage care takers as well?
2. For the four proposed educational delivery methods listed below, please discuss your thoughts and comments on their acceptability and limitations:
    a. In person classroom sessions with our nurse practitioner.
    b. “Office-hours” where a Registered nurse can be called during the week if the patient has any questions in the lead up to surgery.
    c. YouTube videos catered to each type of surgery or pathology a patient may experience.

d. An audio-video booklet. The booklet has a screen on the inside, with videos that describe what to expect pre-, intra-, and post-operatively. Also includes text with important information summarized about your procedure.

Patient preferences and experiences with surgical education were written in summaries, accompanied by specific quotes related to their responses. As per Doria et al. (2018), collaborative or interactive forms of recording such as written transcripts and notes, as well as shared notetaking are preferable for discussion groups. This information is used to support project decision-making based on recommendations from patients (Doria et al., 2018).

Information Use

Following the discussion groups, two authors discussed the themes and ideas captured during the discussion and compared notes to ensure no topic or patient suggestions were missed.

Results:

Participants

Five patients participated across three engagement sessions (2 discussion groups and 1 individual meeting). Formal demographic information was not recorded, but each patient had a variety of lived experience with surgery including cardiovascular surgery, hip and knee arthroplasty, and spine surgery. Both males and females were represented from three provinces in Canada with varying ages and time since surgical experience. One

participant was a local spine patient who had surgery shortly before engaging in the discussion group.

Summary of key discussion points

The current education standard: Patient education via booklet:

Currently, patient education at the QEII hospital is offered via a conversation with the surgeon when the patient is offered surgery. The patient is provided with a 30-page booklet to take home which covers information on their procedure, how to prepare for surgery, and what to expect during their recovery. One patient, who had experience with this booklet found it cumbersome and potentially uninformative: "The booklet didn't really provide the information I was looking for…However, I only skimmed the booklet prior to surgery" and suggested "…there should *be an executive summary at the start*". Another patient expressed concerns about booklets going out of date rather quickly due to advances in surgical care, whereas another patient partner pointed out the flexibility of booklets in being able to provide education in multiple languages easily.

Patient experiences with education:

Five main themes were identified during the discussion groups. The first theme was the importance of managing expectations, with one patient saying, "*fear should also be managed in addition to physical health*". Managing expectations was viewed as important to ensure that patients would have accurate expectations about their surgery and recovery so they could recognize what would be a normal part of their recovery, specifically regarding pain management.

The next theme was regarding multimodal education tools and the ability to offer education which was more specific to the patient. While the discussion highlighted the importance of personalized education as a high priority for patients, the option to provide multimodal education over personalized education was met with agreement as it was recognized that personalized education would be too difficult to offer. For example, one patient reported "*nothing beats one-on-one conversation,*" but acknowledged it would not be feasible for every patient to have regular one-on-one education sessions with surgeons. Another patient disagreed, saying that they found surgeons are "*not great to talk to*".

The third theme identified was related to engaging patient caretakers in the education process. One patient said "*who is your co-pilot?"* when referring to a previous surgery where the surgeon asked who would be helping them in their surgical journey. This patient expressed the importance of this "co-pilot" as they would be another person to retain education and could also ask questions regarding the care of the patient.

The fourth theme was related to difficulties surrounding access to healthcare professionals. For access to healthcare staff, frustration with not being able to easily access a surgeon or a nurse prior to their surgery was noted. This theme was viewed as particularly important given the delay between when a patient is offered surgery and when they actually receive the surgery. While booklets were noted to be useful educational material for referring to common problems and expectations, patients believe it is important to have an expert to whom they can direct their questions.

The final theme was focused on patients' concern about the distance to healthcare centers for receiving education, particularly for those living in rural communities which may

have poor access to technology or lack good quality internet. For educational sessions outside of clinical care which required attending the hospital, this was viewed as potentially burdensome and expensive to patients who would have to commute long distances to receive the education. For patients who live in rural areas, and due to an aging population, interventions which require internet, or the use of a tablet or computer were also viewed as potentially difficult for these patients to access educational resources.

Patient preferences for education delivery:

Four educational delivery tools were provided for patients to discuss how they prefer education to be delivered (Table 5.1). While no specific tool was identified to be superior to any other tool, patients reported "personalized" education as the most desirable method for delivering education. However, they agreed that multimodal education programs would be adequate so as not to overly burden healthcare resources and offer a realistic approach to education. A mixture of classroom sessions, booklets, and access to healthcare staff through some mechanism (such as phone or email) would cover multiple learning modules.

Table 5.1: Patient perspectives on barriers and enablers associated with proposed educational tools

Intervention	**Enablers**	**Barriers**
Online Videos	• Not resource intensive. • Easily accessible for patients who are capable of interacting with the internet. • In house videos allow patients to view videos directly related to them, as opposed to searching	• No way to ensure patients engage with the content independently. • Patients with poor internet or lack skills to operate a tablet/smart phone/ or computer can't access this resource.

	online and possibly finding misinformation.	
Nursing Phoneline	• Allows patients to access education as they come up with questions. • Mitigates retention issues related to the time difference from being offered surgery to receiving it. • Mitigates lack of access to quality internet	• None identified
Audio/Visual Booklets	• Patients get a combination of videos and text to provide education. • Patients can engage with the content at their discretion. • Can provide education incrementally pre-operatively and post-operatively. • Doesn't require the patient to utilize a tablet or computer to access education.	• None identified
Classroom Style Sessions	• Patients and caretakers can attend sessions at the same time. • Viewed as desirable and beneficial to patients who had past experience with this type of education.	• Patients in rural regions, or who live far away will have difficulty accessing this education. • Patients with severe spine disease may not be capable of attending and engaging in these sessions. • Sessions may be too far out from surgery for patients to retain what they learned.

Discussion:

Summary of findings

Engagement sessions with individuals with lived experience of surgery revealed important, patient-centered priorities for educational content and delivery method. Findings have informed our local site's educational planning but hope other ERAS Spine educational efforts can also benefit.

These engagement sessions indicated that patients largely prefer personalized educational resources, with flexibility in mode of delivery whether that be via reading materials, oral communication, or through videos or applications. Having a healthcare staff contact for continued learning when the patient needed it (e.g., asking questions as they arise) was also considered an important component of education. There was no clear preference for method of delivery and patients recognized the benefits and challenges of each. Barriers were noted mostly for classroom-style sessions and online videos. Online videos pose the risk that patients with poor internet access or who are limited in technical capability are not provided equitable access to education. While classroom-style sessions were positively rated for allowing patients and caregivers to receive education simultaneously, it was recognized that these require an extra visit to the hospital by patients. For some patients, this could be difficult depending on the severity of their spinal disease. Furthermore, a classroom session would require resources, namely healthcare staff and facilities, which could be challenging for health systems, at least for regular and ongoing delivery of sessions. The timing of such sessions is also challenging. If education is offered too far away from the patient's surgery date, or too close, it could contribute to the

patient forgetting information. Finally, while engagement sessions didn't fully explore educational content, patients suggested that any spinal surgery education should address fear of surgery and not solely the physical components and impacts of the procedure, as well as manage patient expectations prior to surgery. Patients also reported the importance of education being available for their caregiver as well.

Comparison to the literature

To our knowledge, there is no consensus for how spine education should be delivered or what content should be included. However, we are aware of one report from 2014 that examined best practices for education in outpatient spine surgery (Reiter 2014). While the author reports consistent messaging and regular educational sessions pre- and post-op with a nurse as the delivery method, there are no references or supplemental information to support the best practice of this delivery method (Reiter., 2014). Nonetheless, our engagement initiative suggests that patients value having access to a key contact to answer questions. This access to healthcare staff in the leadup to surgery can also help reduce issues related to retention of educational material in the event education is provided a long time prior to the patient's surgery date, a challenge our patients recognized. A study from 2004 recommends that multiple, consistent education from the same provider is beneficial for retaining educational content (Freda., 2004).

We observed that online resources for patient education were deemed to be beneficial as they are easily accessible (as long as the patient has the ability to access and use the internet for this purpose) and can offer site-specific educational needs. Online resources vetted by surgical sites can help ensure patients receive accurate and trustworthy

information. This is important given the onslaught of information quickly available online. For example, online videos on the platform "YouTube" are popular sites for accessing health information. While videos on spine surgery may be easy to access for patients, a study by Safa et al. (2022) observed that only 33% of spine surgery educational videos could be considered "good" as scored using the DISCERN scale. Another study in the context of vascular surgery also recognized the poor quality of YouTube videos as an educational tool, stating that online videos were only considered "poor" or "fair", and that videos considered "poor" for educational quality also resulted in more views than the higher quality videos (Javidan et al., 2024). Similarly, another study examining online written educational resources for spine surgery observed that of 310 online articles, only six were considered to be at a written comprehension level of below the 7th grade (Long et al., 2018). By providing "in-house" educational materials, surgical teams can provide site-specific information and, ideally, help prevent the patient from looking online to fill in the gaps for their educational needs. These "in-house" materials can help provide easy access to education while minimizing the risk of a patient consuming education which is either not adequate or inaccurate to varying degrees.

Implications for practice

Patient education is an important part of the surgical journey and sets expectations for both the care team and the patient and family. Managing expectations and offering robust educational programs can help facilitate engagement of the patient with their own recovery and can help reduce anxiety and increase satisfaction. However, it is important to deliver education in ways that are patient-informed. In this engagement initiative, we

sought to learn from patients with past surgical experience in an effort to inform our site's educational planning.

While personalized education would be ideal for both healthcare providers and patients alike, particularly if it enhanced the patient's ability to engage with their care, this is rarely possible. Limited hospital resources, whether it be staff, room facilities, or finances make it difficult to cater to individual patient needs. That said, patients told us that a "one size fits all" approach is not sufficient either. A compromise supported in our engagement sessions is a multimodal approach which provides a few options of educational materials from which patients can choose. Patients also reported that our current educational design (a long-written booklet) was insufficient in its one method of delivery and cumbersome due to its length. During the discussion groups, patients emphasized that having caregivers involved with education, and providing education that also acknowledged patients' fears and concerns was paramount.

Patients identified many potential enablers or barriers for proposed educational tools; these were related to the financial, logistic, and staffing limitations of surgical centres, including the spine team at the QEII. Some resources might be easier for a healthcare team to deliver, such as providing online videos or providing booklets to patients. These resources require little follow-up from the patients' care team, are cost effective, and allow the patient access to them at their own convenience. Content such as managing expectations and acknowledging patient fears can easily be added to these materials. Conversely, these resources leave little room for patients to ask clarifying questions. On the other hand, patients identified no barriers to the implementation of education which

would involve a phone line which they could call into and ask questions or to the audio/visual booklets. From a healthcare perspective, the phone line is resource intensive as it required staffing, room space, and would be a substantial cost compared to the other educational interventions proposed. Similarly, the audio-visual booklet would require regular purchasing as opposed to the one-time purchase or creation of an online video or offering semi-regularly scheduled classroom-style sessions. Classroom sessions allow the provision of education to patients and caregivers in the same session, but also require space to facilitate the class and staff to deliver the content and would require patients to make an extra visit to hospital, which may not be practical, or even possible depending on the severity of the patient's disease.

Findings from our discussion group identified that patients would like different types of education delivery methods, rather than any singular method. While this may not be surprising, there are implications for utilization of hospital resources. This information will be reviewed with staff and administration who are involved in the development and approval for education in neurosurgery (e.g., surgeons, nurse educators, physiotherapy, and healthcare administrators) to identify how to best include recommendations from this discussion group.

Limitations and future research

This engagement initiative only included five patient partners. While it was beneficial to have patients with other surgical experiences, there was only one patient with lived experience of spine surgery. Future patient engagement initiatives would benefit from the inclusion of patients at our site who are yet to receive surgery as well as those who

recently had surgery. Future work should also test if a multimodal design is superior to the existing booklet that our group currently offers. Furthermore, identifying what multimodal educational tools look like, and what tools work best together is another important area of study. Only having one patient who had lived experience with elective spine surgery provides a limited perspective on education and spine surgery. However, as this was an exploratory discussion group, other experiences with patient education in other surgical fields could allow us to have a larger breadth of experience with education and surgery. Future work could benefit from a spine specific patient engagement approach.

Conclusion

Patient education is ubiquitous in spine surgery pathways and is the first step to engaging patients to be an active participant in their own care. There are few recommendations or guidelines regarding how spine education should be delivered or even what should be included in it. Including patients to determine preferences on delivery and content of educational materials should encourage better engagement with educational resources. Patients identified that managing fear, including caregivers in education, and access to healthcare staff and educational tools were crucial for engaging with education. Patients identified personalized education as the optimal method of delivery, but recognized that multimodal methods of delivery would be an appropriate compromise due to limited healthcare resources.

Chapter 6 : Content of Enhanced Recovery After Surgery Patient Educational Material in the Spine Surgery Setting: A Review of the Literature and Canada Wide Educational Materials

Ryan Greene[1, 2], Holly Etchegary[1], Sean D Christie[2], and Amanda Hall[3]

1. Faculty of Medicine, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada

2. Department of Surgery (Neurosurgery), Dalhousie University, Halifax, Nova Scotia, Canada

3. Primary Health Research Unit, Memorial University of Newfoundland, St. John's, Newfoundland and Labrador, Canada

Preface:

Ryan Greene developed the study design, conducted the systematic review, abstracted the data, interpreted the results, and wrote the manuscript. Dr. Etchegary helped with interpreting the results and reviewing the manuscript. Dr. Christie assisted data abstraction, and with reviewing the manuscript. Dr. Hall contributed to designing the study, interpreting the results, and reviewing the manuscript.

Introduction:

A core pillar of Enhanced Recovery After Surgery (ERAS) programs for all surgery types is the provision of pre-operative patient education (Ljungqvist, 2014). Traditionally, the aim of pre-op education has been to provide information about the surgery itself and an opportunity for the patient to ask questions. In recent years, patient education has shifted in an effort to facilitate the patient becoming an active participant in their own care, alongside their healthcare team (Graffigna et al., 2018). There has also been some movement to address patient anxiety and fear regarding the outcome of their procedure as research has shown this can negatively impact recovery (Burgess et al., 2019).

While education alone has not been evaluated in many studies, there is some evidence to indicate that pre-operative education can help reduce outcome uncertainty (Landers et al., 2014), manage patient expectations about post-op pain management and recovery, and reduce anxiety scores (Chuang et al., 2016; Kesänen et al., 2016; Kesänen et al., 2017, Lee et al., 2018; Louw et al., 2014). For example, Louw et al. (2016) observed that patients who received preoperative neuroscience education for lumbar radiculopathy were more satisfied with their surgery than those who received conventional education. Furthermore, they observed that patients with the neuroscience education spent 37% less on unnecessary care such as x-rays and visits to family doctors, physical and/or massage therapists (Louw et al., 2013). A study by Papanastassiou et al. (2011) revealed that patients who received a pre-operative care class were significantly more likely to be satisfied with their pain management following surgery compared to those receiving standard care (96% vs 83%, p=0.02). Education should also be provided to patients'

caregivers as their inclusion in the education provision with patients has been shown to improve the patients' capacity for self-care following hospitalization (Lee et al., 2018).

Currently, there is no standardized approach or guidance from the ERAS literature on the content of patient education materials or how they should be delivered. In fact, delivery and content of patient education varies widely in the ERAS literature (Debono et al., 2021a). Without a shared understanding of how best to deliver education and what content leads to optimal patient outcomes, it is challenging to implement a successful patient education component.

In this chapter, we sought to determine: a) how pre-operative education was delivered to patients undergoing elective spine surgery for a degenerative disease as part of an ERAS protocol and b) what content was included in education materials. This work can inform the design of future educational content and delivery modalities.

Methods:

We used a systematic review design following PRISMA guidelines to answer study questions. The protocol for this manuscript was published in advance on open science framework (Appendix 6.1).

PICO question: In peer-reviewed published studies or Canadian surgical spine centers implementing and/or testing ERAS for spinal surgery, what is the content of the ERAS patient education, and how is the education delivered?

Search strategy:

We used two information sources for this review as our pilot test of obtaining the actual education materials from ERAS interventions in the published literature revealed limited results.

1. Primary source - Systematic Search of the Literature: We employed the Peer Review of Electronic Search Strategies (PRESS) guidelines to develop the search strategy (Appendix 6.1), developed in consultation with a health research librarian (MS). We conducted the search in three databases: PubMed, CINAHL and Embase from inception to February 2024. To supplement the electronic search, we used forward and backward citation tracking.

2. Secondary source – ERAS interventions used at spine surgery centres across Canada: We used the Canadian Spine Outcomes Research Network (CSORN), a national registry of spine surgery centres (CSORN, 2024) which includes 18 centres representing about half of all spine surgery centres in Canada. The websites of each of these centers were assessed in March 2024 to determine if the center was using an ERAS intervention. Content expert SDC also identified centres not part of the CSORN using an ERAS intervention.

Eligibility Criteria:

Studies evaluating ERAS interventions or Canadian spinal surgical centres using an ERAS intervention were included if they met the inclusion and exclusion criteria outlined in Table 6.1.

Table 6.1: Inclusion and exclusion criteria for spine surgery ERAS interventions published in the literature or used in Canadian Spine Surgery centres.

Criterion	Inclusion	Exclusion
Population	Adult patients (aged 18 and older) who underwent surgery (decompression alone or decompression and fusion) for a degenerative condition of the spine including: lumbar stenosis, disc herniation, spondylolisthesis, and cervical myelopathy.	Pediatric population, surgery which had an indication of tumour, infection, deformity or trauma, and minimally invasive approaches.
Intervention	ERAS intervention that included protocols for pre-, peri-, and post-operative phases AND had patient education included in the pre-operative phase.	• ERAS interventions which did not have protocols for all 3 phases (e.g. fast track with only 1-2 phases, early mobilization only) • ERAS interventions that did not have a patient education component
Comparison	n/a	n/a
Outcome	n/a	n/a

Selection Process:

All papers from the literature search were screened for inclusion by one reviewer (RG). In the event there was uncertainty about inclusion, a second, expert reviewer decided whether the paper was included or not (AH, SC). Websites for each of the 18 CSORN centres were screened by one author (RG).

Data extraction and synthesis:

Data variables: General descriptive characteristics of the ERAS intervention including year and country of implementation, and the ERAS intervention components were

extracted. The patient education ERAS education component content analysis followed the Template for Intervention Description and Replication (TIDieR) framework as a guide for data extraction. This included extraction of the name of the education material, purpose of the education, education materials, who provided the education, mode of delivery, setting, frequency and duration, tailoring, modifications, planned fidelity assessments, and actual fidelity assessments. Additionally, the content of all the education materials was extracted to allow for qualitative description and coding of the type of content used in ERAS patient education.

Data extraction procedure: For all included ERAS interventions, one author (RG) abstracted all data into data extraction templates in Microsoft Excel. In many cases, the actual patient education material(s) (PEM) used in an ERAS intervention was not provided as part of the published study or as a supplementary file. For situations in which the PEM was not freely available, RG emailed the study author/Canadian spine center to request access. Data was abstracted as it appeared in the studies, or information provided by study authors and/or from websites.

Data Synthesis: Information was summarized separately in three sections: delivery methods, content, and fidelity and tailoring. Content analysis was used to describe the informational areas of all educational tools. Educational materials were read and reread in order to identify all content areas included in the PEMs. Educational content was compared and contrasted through repeated readings of PEMs and content was categorized into descriptive categories using labels that described the different topic areas included in PEMs. Frequency of use for each resulting category across studies were reported.

Results:

Systematic Search of the Literature:

Our primary information source, the systematic search of the literature, identified 17 studies implementing an ERAS intervention that included a patient education component. The secondary search of the 18 Canadian surgical centers identified one additional centre that was using an ERAS intervention including a patient education component. This resulted in a total of 18 ERAS interventions for inclusion in this review (Figure 6.1).

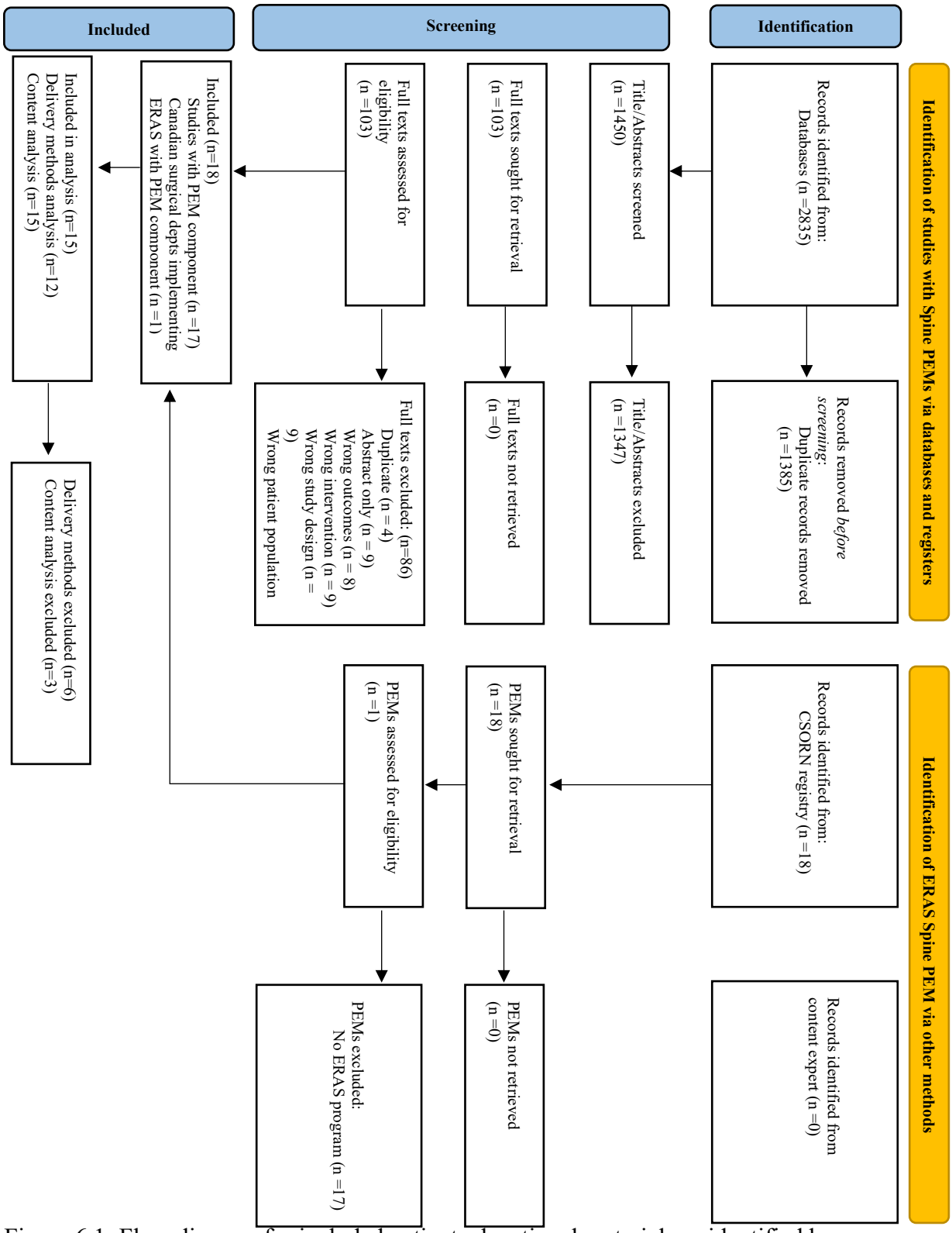


Figure 6.1: Flow diagram for included patient educational materials as identified by studies from the systematic review and from the CSORN website.

ERAS intervention characteristics (Table 6.2)

All included studies had full ERAS interventions (pre-, peri-, and post-op); patient education was used in all ERAS interventions during the pre-operative phase. While education was not the only strategy used, it was the most common. Other common pre-operative components included fasting, discharge plan, carbohydrate (CHO) loading, nutrition advice, chlorhexidine gluconate (CHX) shower, and lifestyle advice. Common peri-operative components of ERAS include multimodal analgesia aimed at reducing opioid reliance, use of as few drains and catheters used as possible, prevention of hypothermia, providing antibiotic prophylaxis immediately before surgery, and use of tranexamic acid. Common post-op components include multimodal analgesia to reduce reliance on opioids, early ambulation, early nutrition, early removal of drains and catheters, use of stool softeners, and wound management. No studies provided their patient educational materials as part of the manuscript. We reached out, via email, to request access to that information but no materials were provided. Two authors responded stating their educational material was in Chinese and would not be translated or that they no longer had access to the educational materials. However, they did provide a summary of what information was included in their pamphlets.

Table 6.2: ERAS intervention characteristics

ERAS Intervention Source **Country**	**Patient pathology*** **Types of surgical procedures** Decompression (D) OR Decompression + Fusion (D+F)	**Pre-operative Components**									**PEM provided**	**Useable data**	
		Education	**Fasting**	**Discharge plan**	**CHO**	**Nutrition**	**CHX**	**Stop Smoking**	**Stop Alcohol**	**Exercise**		**Content**	**Delivery**
Smith 2019 United States	Lumbar - All 4 pathologies D + F	x		x							No	Yes	Yes
Li 2018 China	Cervical - myelopathy D	x	x								No	Yes	No
Bradywood 2017 United States	Lumbar -Stenosis, Spondylolisthesis D + F	x				x	x				No	No	No
Debono 2021 France	Cervical - Spinal stenosis D + F	x	x								No	Yes	Yes
Debono 2019 France	Lumbar or Cervical - Spinal stenosis, disc herniation, myelopathy D + F	x	x								No	Yes	Yes
d'Astorg 2020 France	Lumbar - disc herniation, spinal stenosis. Cervical - myelopathy D + F	x		x							No	Yes	Yes
Flanders 2020 United States	Cervical or Lumbar - All 4 pathologies D + F	x		x		x		x	x		No	Yes	Yes
Heathcote 2019 United States	Lumbar or Cervical- All 4 pathologies D + F	x			x	x					No	Yes	Yes

Duojun 2021 China	Lumbar - Disc herniation. D	x	x								No	Yes	Yes
Garg 2021 India	Cervical or Lumbar - All 4 pathologies[+] D + F	x	x		x		x			x	No	Yes	Yes
Kerolus 2021 United States	Cervical or Lumbar - All 4 pathologies. D + F	x	x								No	No	No
Li 2021 China	Lumbar - Stenosis D + F	x	x			x					No	Yes	Yes
Wang 2022a China	Lumbar – stenosis, disc herniation, D + F	x	x		x						No	Yes	Yes
Wang 2022b China	Lumbar – all pathologies D + F	x			x						No	Yes	No
Chen 2022 China	Lumbar – all pathologies D + F	x	x		x		x				No	Yes	Yes
Cui 2022 China	Lumbar -stenosis, spondylolisthesis D + F	x	x		x	x		x	x		No	Yes	No
Porche 2023 United States	Cervical - myelopathy D + F	x				x					No	No	No
Vancouver Hospital Canada	Lumbar – all pathologies D + F	x	x	x	x	x	x	x	x	x	Yes	Yes	

*Pathologies: disc herniation, stenosis, spondylolisthesis, and cervical myelopathy

Patient Education Synthesis

Three of the 18 ERAS interventions identified (Bradywood et al., 2017; Kerolus et al., 2021; Porche et al., 2023) provided no useable information regarding delivery methods, content, or adherence and tailoring. As a result, they were excluded from the following

synthesis. A further three did not provide information regarding the PEM delivery method (Cui et al., 2022; Li et al., 2018; Wang et al., 2022b).

PEM Delivery Methods (n=12, Table 6.3)

Education was delivered to patients most commonly through written materials such as booklets or leaflets (Duojun et al., 2021; Flanders et al., 2020; Garg et al., 2021; Li et al., 2021; Smith et al., 2019), through verbal communication (e.g., in-person education sessions or consultations with healthcare staff, and/or online via a smartphone app (Debono et al., 2019; and Debono et al., 2021b), (Chen et al., 2022; Wang et al., 2022a; Li et al., 2021; Debono et al., 2019; Debono et al., 2021b).

Table 6.3: Delivery of patient educational materials based on the TIDieR criteria.

Author/Year	**What (materials)**	**Who**	**How**	**Where**	**When/How much?**
1. d'Astorg 2020	Not reported	Surgeon, Anesthesiologist, PT ERAS RN	Not reported	Not reported	Not reported
2. Debono 2019	Online education material	RN	Smartphone app	Hospital	At pre-op consultation and available at patient's convenience
	Individual education session	Surgeon, Anesthesiologist, PT, ERAS RN	In-person consultation	Hospital	Pre-op one session
3. Debono 2021	Online education material	RN	Smartphone app	Hospital	At pre-op consultation and available at patient's convenience
	Individual education session	Surgeon, Anesthesiologist, PT, ERAS RN	In-person consultation	Hospital	Pre-op one session

4. Duojun 2021	Written educational material	RN implied	Not reported	Hospital implied	Pre-op
	Psychological counseling and education	RN + PSYCH	In-person session	Hospital implied	Pre-op (Number and length of sessions not reported)
5. Flanders 2020	Written educational material	Not reported	Not reported	Not reported	Pre-op
6. Garg 2021	Written educational material	N/A	Handouts	N/A	Pre-op when offered surgery
7. Heathcote 2019	Not reported	RN	Not reported	Not reported	Not reported
8. Li 2021	Written educational material	Not reported	Handouts	Not reported	Pre-op
	Verbal communication	Not reported	In-person implied	Not reported	Pre-op
9. Smith 2019	Written material	Not reported	Information letter	Neurosurgery clinic	Pre-op
10. Wang 2022a	Verbal communication	RN	Not reported	Hospital implied	Pre-op
11. Chen 2022	Verbal communication individually implied	Not reported	In-person implied	In clinic/ hospital implied	Pre-op
Surgery Depts implementing ERAS					
12. Vancouver General Hospital Spine Surgery Institute	Online education material	Not reported	Website	Not reported	Pre-op
	Written material		Booklets		
	Group education session (unclear If mandatory)	RN, PT, OT	In-person and/or virtual (blended)	Hospital or online	Pre-op 1 session, 3 hours
	Individual education session (mandatory)	RN and/or anesthesiologist (dependent on co-morbidities)	In-person or phone, depending on patients' comorbidities	Pre-admin clinic or phone	Pre-op (2 weeks to 2 days prior to surgery) 1 session 2-3 hours

Patient education content (n=15, Table 6.4)

Using content analysis, we divided the content of the patient education components of the ERAS interventions into eight topic areas: surgical processes, expectation management, medication/pain management, lifestyle factors, discharge criteria, ERAS interventions, psychological counselling, and logistical information. Although we were unable to obtain any of the PEMs from the included studies, we did use information from the intervention descriptions provided within each of the studies and the patient educational materials from the Vancouver Spine Surgery Institute. Most of the interventions included information about surgical processes (n=11) describing patients' scheduled procedure (Cui et al., 2022; d'Astorg et al., 2020; Debono et al., 2019; Debono et al., 2021b; Duojun et al., 2021; Flanders et al., 2020; Garg et al., 2021; Heathcote et al., 2019; Li et al., 2021; Smith et al., 2019; Vancouver Spine Surgery Institute, 2024). Also common was information related to expectation management (n=9) to help prepare patients for what to expect following surgery (d'Astorg et al., 2020; Debono et al., 2019; Flanders et al., 2020; Garg et al., 2021; Li et al., 2021; Smith et al., 2019; Vancouver Spine Surgery Institute, 2024; Wang et al., 2022a; Wang et al., 2022b).

Roughly a third of the interventions provided education on a number of topics:

- Medications that might be used to control their pain and provided information on what is considered a "normal" amount of pain (n=6) (d'Astorg et al., 2020; Debono et al., 2019; Debono et al., 2021b; Duojun et al., 2021; Heathcote et al., 2019; Vancouver Spine Surgery Institute, 2024).

- Lifestyle factors (e.g., smoking status) that could affect recovery (n=5) (Duojun et al., 2021; Heathcote et al., 2019; Flanders et al., 2020; Smith et al., 2019; Vancouver Spine Surgery institute, 2024).
- Discharge criteria that must be met to discharge them from hospital (n=5) (Debono et al., 2021b; Garg et al., 2021; Heathcote et al., 2019; Li et al., 2018; and Vancouver Spine Surgery Institute, 2024).
- ERAS intervention and its benefits for their care (n=5) (Cui et al., 2022; Li et al., 2018; Li et al., 2021; Vancouver Spine Surgery Institute, 2024; and Wang et al., 2022b).

Much less commonly, descriptions of the patient education content of the ERAS interventions included information about psychological counselling to reduce fear and anxiety (Duojun et al., 2021) (n=1) and site-specific information such as parking or visiting hours (Vancouver Spine Surgery Institute, 2024) (n=1). A complete description of the content included can be found in Appendix 6.2 and Appendix 6.3.

Table 6.4: Content of the educational material identified from the literature and from the Vancouver Spine ERAS group based on the TIDieR criteria.

Type of education included	**Heathcote 2019**	**Duojun 2021**	**d'Astorg 2020**	**Debono 2019**	**Debono 2021**	**Flanders 2020**	**Garg 2021**	**Smith 2019**	**Li 2021**	**Li 2018**	**Wang 2022b**	**Chen 2022**	**Cui 2022**	**Wang 2022a**	**Vancouver Spine ERAS**
Surgical Processes (n=11) Description: Includes information on the surgery itself, risks of the surgery, or how the	X	X	X	X	X	X	X	X	X				X		X

surgery addresses the patient's pathology.															
Expectation management (n=9) Description: Preparing the patient for what to expect following surgery. Could include pain management during recovery, potential complications or expected post-operative mobilization, and what the patient can expect for their discharge.			X	X		X	X	X	X		X			X	X
Medication/pain management (n=6) Description: Included information on pre- and/or post-operative medication for pain management, or medication which was multimodal and opioid sparing. Pain management also included information on "normal" amounts of pain.	X	X	X	X	X										X
Lifestyle management (n=5) Description: Smoking and alcohol cessation were included as lifestyle management on which patients were educated. Other comorbidities which could accompany lifestyle, such as diabetes and nutritional information were also included.	X	X				X		X							X

Discharge criteria (n=5) Description: Information regarding what patients would need to accomplish in order to be discharged home from hospital. Could include goals such as mobilization, resuming normal diet, and appropriate pain management.	X				X		X			X					X
ERAS education (n=5) Description: Detailed information specific to the ERAS program itself. Included information on the benefits of ERAS over conventional care, such as efficient discharge, and also covered expectations of the patient for the role in their own care, such as early mobilization.									X	X	X		X		X
Psychological Counseling (n=1) Description: Psychological education provided by a psychologist, and/or targeted education to reduce patient fear and anxiety.		X													
Site-specific Information (n=1) Description: Information regarding the operating room and recovery unit, or details on parking, visitations and organizing a stay near the hospital if necessary. Items potentially needed for															X

the inpatient stay, or for at home recovery also listed, such as a checklist of items to bring to hospital.															
Number of education categories within each study PE component	4	4	3	3	3	3	3	3	3	2	2	2	2	1	7

Fidelity and tailoring

Two studies (Wang et al., 2022a; Cui et al., 2022) reported on adherence to the patient education component of ERAS interventions. Both observed high rates of adherence, reporting that 100% and 97% of patients used the educational materials (Wang et al. (2022a); Cui et al. (2022)). No studies provided clarification on whether the delivery of the educational material could be tailored to patient preferences or needs. However, one of the ERAS interventions (Duojun et al., 2021) allowed for tailoring of the patient education content, depending on the patient's need for psychological counseling and/or supplemental treatment for anxiety or fearfulness.

Discussion:

To our knowledge, this is the first comprehensive content analysis of the educational components of Spine ERAS interventions. All identified ERAS interventions reported including a patient education component, but few provided more than superficial detail about how the patient education component was delivered and the content areas covered. From the limited information available, we found little consistency in terms of delivery method. Most patient education was delivered using multiple methods including some

form of written education, such as a handout, combined with an in-person or virtual education session delivered by a RN usually with other members of the surgical and post-op team (surgeon, anesthesia PT, OT). Only one ERAS intervention reported use of in-person or over-the-phone educational counselling and classroom-style sessions. In terms of content, information about the surgical process (e.g., a decompression or decompression and fusion) and expectations for post-operative pain, mobility, and discharge were the most commonly reported. Only two provided education targeting patient fear and anxiety and only one intervention reported providing site-specific information (e.g., information about parking or visiting hours). It is important to note that our assessment of patient education delivery and content is based solely on the information study authors reported in their papers as the education materials themselves were not available for us to review. Thus, more topics may have been covered but not discussed in the articles. For example, the only material we were able to review was from the Vancouver Hospital ERAS intervention and, upon reviewing all of its materials, we identified seven different topics. Perhaps the most important take away from our analysis is that none of the delivery methods or education topics covered in our review were described in sufficient detail to allow for replication in practice, severely limiting the ability to implement or evaluate them.

Comparison to the literature

Our finding that patient education was reported to be a component of all the Spine ERAS interventions we identified for this review is not surprising given that patient education is

promoted as a key component by the ERAS society for other ERAS areas (ERAS Society, 2024.

We found that information on patient education delivery methods and content were poorly reported, and we were not able to access most education materials. This was echoed in the recent consensus statement recommendation that "further research is needed to determine the timing, mode of delivery, specific intervention, and specific patients that would benefit most from preoperative education and counselling" (Debono et al., 2021a). This lack of intervention detail and poor access to materials is not new to this field of research. Indeed, a similar review on ERAS education across different surgical fields also observed little information about delivery and content (Jain et al., 2023). While we recognize that authors are sometimes challenged by word limits to provide detailed intervention descriptions, within the last ten years, the ability to publish supplemental materials as online resources alongside peer-reviewed journal articles has increased dramatically. Thus, given that the articles in this study have all been published within the last six years and in open-access journals, we expected more thorough reporting. Copyright issues may be another reason researchers may be reluctant to publish their educational materials.

Implication for practice and research

The major implication of this work is how little we know about how ERAS patient education is delivered and what content has been included. For practice, this means that while education appears to be a common element in ERAS interventions, programs are reporting what they are doing differently, making it challenging to understand the best way to deliver education in practice. Because of these differences in the reporting of

education delivery and content across ERAS interventions, we also can't recommend any one strategy. Moreover, this lack of description makes it impossible to assess their impact. If we are to advance our understanding of patient education for spine surgery, we first need to know how and what is being delivered in order to know if these components are actually effective. For any future research on patient education components of ERAS interventions, we recommend developing a logic model demonstrating how the education component is meant to work. In addition, few studies reported adherence to the patient education component of the ERAS intervention making it even more difficult to understand how practical the education is to deliver. Overall, research is needed on adherence rates or engagement with educational content.

Limitations

Our results are based on patient education in ERAS interventions found in the literature supplemented by a review of spine centres known to be using ERAS interventions in Canada. While it was beyond the scope of this thesis, it is possible that ERAS interventions at spine centres in other countries could have more well-documented and/or additional patient education information that might change our findings. Another limitation of this work is that only one viewer coded and abstracted the educational material from the published studies included, as well as the educational materials from the Vancouver Spine ERAS program. Limited availability of information from study authors and their papers does reduce our ability to strongly recommend any of the included educational content or delivery observed. As such, future ERAS research would benefit

from specific information regarding educational content and delivery, or preferably, availability of educational content as well.

Conclusion

While patient education is considered an important component of ERAS interventions for spine surgery, few studies report how education is delivered, who delivers that information, or even what is included in any patient educational material. Even though the ERAS consensus statement describes that education is a crucial component of ERAS pathways, future work is needed to provide more detail on how patient education can be most effectively implemented in practice.

Chapter 7 : Discussion

The aim of this thesis was to provide an up-to-date assessment of the effectiveness of spine surgery ERAS programs, the types of strategies that might be essential as well as feasible for the particular context at the QEII with a specific focus on the strategy of patient education in terms of content and delivery mechanisms. The results of this work will be used to inform the design, development, and evaluation of an ERAS intervention at the QEII. We conducted three studies (one meta-analysis, one narrative review, and one clinical audit) and two discussion groups focused specifically on healthcare provider and patient perspectives of ERAS strategies to accomplish this goal. These are outlined in Chapters 2-6 of this thesis and include an in-depth discussion of the findings, how they compare to the literature (where appropriate), strengths and weaknesses, and implications for practice and research. Here, I provide a brief summary of the findings from each chapter of my thesis and discuss what my findings add to the literature regarding ERAS for spine surgery, considerations for future research, implications for practice, and an overall conclusion.

Summary of findings

In chapter 2, we reported the results of stakeholder discussion groups which reviewed a comprehensive list of ERAS strategies in order to evaluate their suitability for inclusion in an ERAS intervention for scheduled spine surgery at the QEII Hospital in Nova Scotia, Canada. We convened a diverse group of healthcare providers for these discussions but there were notable gaps as we only extended invites to providers employed in our surgery department. Therefore, some health professionals who may be involved in the surgical

pathway (e.g., physiotherapists) were not invited, representing a limitation of our stakeholder representation. Stakeholders recommended the inclusion of 23 of the 26 pre, peri, and post-operative strategies reviewed during these sessions. Eight of the identified strategies were already a part of routine management at QEII (e.g., optimization of comorbidity medical management, routine prophylaxis, or use of minimally invasive approaches when feasible), leaving a potential 15 additional strategies to include in an ERAS intervention. Implementation of these strategies will impact the duties and/or practice of multiple types of providers which will require varying degrees of practice change.

In chapter 3, we reported on a systematic review and meta-analysis examining the efficacy of existing ERAS programs reported in the literature. Overall, ERAS for spine surgery has not been extensively or rigorously studied. While our SRMA identified 12 individual studies that examined ERAS for spine surgery and other systematic reviews for ERAS in spine surgery, several methodological issues with this work were identified. Nevertheless, our results demonstrated that implementing an ERAS program for elective spine surgery resulted in a significant decrease in LoS by 1.03 days (95% CI: -1.36 to -0.70; $p<0.001$; $I^2=93\%$), without increasing the risk for re-admission to hospital at 30-, 60-, or 90-day follow-up. While this result is promising, our confidence in this finding is limited because all studies included in the review used uncontrolled before and after designs (offering a low level of evidence), 11 of 12 studies did nothing to mitigate confounding factors, and all were subject to serious risk of bias. We also noted additional gaps in the ERAS literature. None of the studies measured adherence to the ERAS

intervention, provided a logic model or rationale for the interventions, or measured process outcomes.

In chapter 4 we presented the results of a clinical audit and descriptive cohort study to provide a clearer picture of the factors delaying discharge at QEII and to identify any gaps in patient understanding of these factors. Roughly half of the patients who underwent spine surgery during the study period required an extended LOS (beyond one-night). Issues surrounding mobility were the most common hospital-based reasons for prolonged stay followed by urinary retention. Issues outside the spine surgery department's purview (such as trying to discharge a patient to a different hospital or rehab) took up a greater percentage of the reasons for non-discharge after the third overnight stay in hospital. Patients had different opinions on why they remained in hospital. Patients expressed issues surrounding pain management as the most frequent contributor as to why they remained in hospital. Compared to nursing staff, they also underreported urinary retention. Patients did, however, recognize that mobilization was an important component to their recovery, and also frequently reported that their lack of mobilization was a factor contributing to their discharge. Of note, this study was conducted during the Covid-19 pandemic, and it is unclear if these patients are representative of the typical patient population that moves through our spine surgery department.

In chapter 5, we report on the results of a discussion group held with patients to determine how they engage with educational material and their preferences for education delivery. Patients largely prefer personalized educational resources, with flexibility in mode of delivery whether that be via reading materials, oral communication, or through videos or

applications. Having a healthcare staff contact for continued learning when the patient needed it (e.g., asking questions as they arise) was also considered an important component of education. There was no clear preference for method of delivery, but patients discussed the timeliness of the education delivery – they don't want to be educated too far away from the procedure which risks failing to remember important information, but they do want enough time between education delivery and their procedure to digest the information and have their questions answered. While the discussion group didn't fully explore educational content, patients suggested that any spinal surgery education should address fear of surgery and not solely the physical components and impacts of the procedure.

Finally, in chapter 6, we carried out a narrative review of patient education in spine surgery ERAS interventions to determine how education was delivered to patients undergoing elective spine surgery as part of an ERAS intervention and what content was included in education materials. Patient education was included in all of the ERAS interventions we identified but only superficial detail regarding delivery and content of the materials was provided. In fact, we were only able to review patient education materials from one of the interventions identified as part of this review. From the limited information available, we found little consistency in terms of delivery method. Most used several methods including some form of written education, such as a handout combined with an in-person or virtual education session delivered by a RN usually with other members of the surgical and post-op team (surgeon, anesthesia PT, OT). In terms of content, information about the surgical process (e.g., a decompression or decompression

and fusion) and expectations for post-operative pain, mobility, and discharge were the most commonly reported. It is important to note that our assessment of patient education delivery and content is based solely on the information study authors reported in their papers as the education materials themselves were not available for us to review (even after several attempts to retrieve the materials from study authors). Thus, more topics may have been covered but not discussed in the articles.

Contributions to the literature

This thesis highlights that we know very little about the effectiveness of ERAS interventions for spine surgery. We know nothing about their implementation in practice and very little about the role of education in terms of its content and delivery as part of ERAS interventions. We learned that stakeholders are generally in favor of almost all possible ERAS strategies, only excluding three of a possible 26. While their positive engagement is promising, implementation of all of these strategies represents a significant challenge for the health system. Our clinical audit suggests that we should implement strategies targeting mobility and urinary retention first and that our patient education materials must be updated to address expectations around pain and its role in recovery and discharge decision-making. Moreover, our review of patient education materials and discussion group with patients identified that offering different modes of delivery is common in the literature and preferred by patients and that education content should be supplemented with opportunities to ask questions of the healthcare team. Similar to our findings from the stakeholder discussion group, this will require additional work and may warrant further investigation to identify, prioritize, and evaluate modes of delivery.

Strengths and limitations

An in-depth discussion of the strengths and limitations of each study and discussion group are provided in the individual chapters. Here, we provide a brief summary of this information. This thesis is strengthened by the robust methods employed across the studies and discussion groups that were conducted. Protocols for each of the studies were prospectively registered on Open Science Framework. The systematic reviews followed recommended guidelines outlined by Cochrane, PRISMA, PRESS, and/or GRADE and TIDieR where appropriate, and used two reviewers for all stages of screening. The clinical audit was strengthened by following the reporting guidelines for observational studies (STROBE) (Vandenbroucke et al., 2007), including all patients who underwent elective spine surgery during the study period, and by tracking reasons for extended stay directly from the source of that decision making (nurse manager) rather than from a review of patient charts. The review of patient education materials was strengthened by an exhaustive search for all education materials in Canadian ERAS programs including follow-up with study authors to request access to the materials. Finally, the two discussion groups reported in this thesis followed best practices for stakeholder and patient engagement sessions (Doria et al., 2018).

In terms of limitations, the clinical audit took place during the Covid-19 pandemic, and we can't know with certainty that our findings apply to the patient group that attends for elective spine surgery under normal circumstances. In addition, representativeness among participants in the stakeholder discussion groups and the patient discussion group could have been improved. There were some provider opinions not included in the stakeholder

groups. For example, because physiotherapists are not employed in our surgical department, they were not invited to attend the discussion groups. In addition, while anesthesiologists were invited, none attended the discussion groups. Finally, the patient discussion group did not exclusively include patients who had experience with spine surgery; patients with lived experience of any type of surgery were included.

Future research

Essentially, there are several areas to focus on for future research. Our recommendations for future research are based on the results of each of our chapters and align nicely with a recent opinion paper on the state of science for ERAS literature by Henrik Kehlet (2020). First, it is important to establish a clear understanding of what strategies are being used in spine ERAS interventions, how they are being delivered, the outcomes each strategy is meant to produce, and how that is meant to eventually reduce length of stay. In other words, logic models for these interventions should be produced and reported in the literature in sufficient detail to support evaluation and replication. Early researchers in this field (Kehlet and Wilmore, 2008) started working in this direction but the research in this field has gotten away from this - really focusing on secondary outcomes (primarily LOS and readmission) that are important to the health system. The research community should return to its foundations to formally develop a logic model showing the connections between the strategies, specific clinical outcomes, and resulting secondary outcomes. This is particularly important since there are so many potential strategies that can be implemented at each surgical phase. It is important that we implement strategies with the most clinical value. When complex interventions have too many moving parts,

there is a risk of provider exhaustion such that none of the strategies are implemented properly. For example, there are cases where the ERAS strategies are implemented properly only during the course of a study when they are being overseen by an ERAS coordinator but when that person is removed, there is a return to routine practice (Arrick et al., 2018).

Second, spine ERAS research would also benefit from studies using much more robust designs. Ideally, spine ERAS researchers would use randomized designs. In cases where that is not possible, researchers should follow the example of Debono et al. (2021b) and control as many confounding factors as possible when conducting before-after studies and use propensity score matching.

Lastly, patient education for spine ERAS interventions requires significant development. This process should include both patients and relevant providers and follow best practices for the co-design of patient education materials (McMullen et al., 2023). The literature on spine surgery, patient education, and our patient discussion group suggested that multiple methods of delivery are important to patients. One of the desired options - having someone from the team to talk to on an as-needed basis – is likely expensive to implement. Research on this strategy such as how often it is likely to be used and key outcomes from patient and health system perspectives is needed. It is not uncommon for learners across many situations to desire designated ongoing support. While this is often not considered scalable, there are different options that can be explored (e.g., group education sessions).

Conclusion

The origins of ERAS interventions were based on promising work by Kehlet and Wilmore (2008), which reported on the implementation of a multi-strategy intervention to improve outcomes for patients undergoing surgery. Since that time, ERAS has evolved; it has been adopted, modified (to include new strategies), and evaluated by many surgical specialties and there is some evidence of effectiveness (Kehlet, 2020). However, these evaluations have primarily focused on length of stay and readmission rates. Research on the effectiveness of the individual strategies that have been developed and included in ERAS interventions has not kept pace with the adoption, implementation, and modifications of ERAS strategies. Some of this has been summarized in a recent consensus paper – which reported quite a lot of strategies supported primarily by low-quality evidence (Debono et al., 2021a). One of these additional strategies is patient education, recommended as a core component of ERAS interventions. However, there is not enough known about how and why this strategy affects the surgical recovery process. Researchers, funding bodies, and health system decision-makers would benefit from consideration of our recommendations for future research when planning or implementing spine ERAS interventions.

Recommendations:

"While this thesis found many gaps in the understanding of ERAS effectiveness and implementation, I have highlighted the key recommendations I would make for developing an ERAS protocol for elective spine surgery:

1. Barriers to discharge
    a. Mobilization:

        We observed that mobilization was the most common factor which prevented patients from being discharged from hospital following spine surgery. As a result, early mobilization as part of an ERAS protocol could be particularly effective in this cohort.

    b. Urinary retention:

        While ERAS protocols speak little to urinary retention as a problematic barrier to discharge, we would recommend the use of a bladder scanner to help expedite the discharge of patients who may be identified as having bladder issues.

    c. Multimodal pain management:

        Multimodal pain approaches are common in the ERAS literature, regarding both the intra-operative anesthetic, as well as for post-operative pain control, to reduce reliance on opioids. Due to common side effects such as nausea/vomiting with opioids, this could reduce the patient's ability to resume nutrition earlier or mobilize. Furthermore, we identified that poor pain management was frequently observed in our cohort for the barriers to discharge study, and a multimodal approach to pain management could be particularly beneficial.

2. Patient education
    a. Co-development of educational resources:

Patient education is ubiquitous in the spine literature, but aside from healthcare required criteria that is provided in educational resources, our patient engagement sessions discussed that other factors outside of the surgical teams' ideas for educational content are important for them. For example, expectation setting for post-operative pain management, as well as easing patient anxiety about their procedure were important to patient partners. Working with patient partners with lived experience with surgery could help improve educational offerings, specific to the needs of patients who receive spine surgery. Most ERAS protocols use improved education as a key pillar of their program, working with patient partners to improve education could provide a perspective that is more patient centric.

b. Multimodal approach to patient education

Similar to educational content being poorly described in the literature, the delivery of that material is also limited in description. Offering multiple options for education can allow patients access to education in a manner that allows them to learn best, and also allows patients opportunities to still receive education, even if they have technological, geographic or other limitations that may preclude them from a singular educational offering.

3. Measuring compliance

Compliance to ERAS protocols was very poorly described in the spinal literature, making it challenging to determine if ERAS was truly even effective in those studies. As per the ERAS Society, the RECOvER checklist has compliance as a requirement for the assessment of an ERAS program (Elias et al., 2018). Assessing

compliance is also important for determining metrics in an ERAS program which are effective, and which ones are less efficacious, or maybe not being performed often enough.

4. Measuring patient reported outcome measures:

   While most early ERAS literature focuses on a reduction in LoS, without compromising quality of care (measured as re-admission to hospital), other metrics are important to consider as well, particularly those related to patient reported outcome measures. While the aim of an ERAS program is to reduce LoS, it would also be important to be cognizant of other factors that directly affect patients. For example, measuring pain scores post-operatively to ensure the patients are equally (or better) managed pain wise compared to conventional care should be a priority. Furthermore, in spine surgery, the Oswestry disability index is a measure of functional ability, relative to the patient's spinal disease. It would also be recommended to measure this metric, to see if patients improve similarly following surgery compared to patients not in an ERAS cohort."

References

Abduljabbar FH, Teles AR, Bokhari R, Weber M, Santaguida C. Laminectomy with or Without Fusion to Manage Degenerative Cervical Myelopathy. Neurosurg Clin N Am. 2018;29(1):91-105. doi:10.1016/j.nec.2017.09.017

Ali ZS, Ma TS, Ozturk AK, et al. Pre-optimization of spinal surgery patients: Development of a neurosurgical enhanced recovery after surgery (ERAS) protocol. Clin Neurol Neurosurg. 2018;164:142-153. doi:10.1016/j.clineuro.2017.12.003

Allen RT, Garfin SR. The Economics of Minimally Invasive Spine Surgery: The Value Perspective. Spine. 2010;35(26S):S375. doi:10.1097/BRS.0b013e31820238d9

Andersson GB. Epidemiological features of chronic low-back pain. The Lancet. 1999;354(9178):581-585. doi:10.1016/S0140-6736(99)01312-4

Archer K, Bird ML, Haug C, et al. Patients' Experience and Expectations of Lumbar Spine Surgery for Degenerative Conditions: A Qualitative Study. The Spine Journal. 2015;15(10, Supplement):S99-S100. doi:10.1016/j.spinee.2015.07.046

Arrick L, Mayson K, Hong T, Warnock G. Enhanced recovery after surgery in colorectal surgery: Impact of protocol adherence on patient outcomes. J Clin Anesth. 2019;55:7-12. doi:10.1016/j.jclinane.2018.12.034

Banczerowski P, Czigléczki G, Papp Z, Veres R, Rappaport HZ, Vajda J. Minimally invasive spine surgery: systematic review. Neurosurg Rev. 2015;38(1):11-26; discussion 26. doi:10.1007/s10143-014-0565-3

Barbosa TP, Raposo AR, Cunha PD, et al. Rehabilitation after cervical and lumbar spine surgery. EFORT Open Rev. 2023;8(8):626-638. doi:10.1530/EOR-23-0015

Basil GW, Wang MY. Trends in outpatient minimally invasive spine surgery. J Spine Surg. 2019;5(Suppl 1):S108-S114. doi:10.21037/jss.2019.04.17

Bardin LD, King P, Maher CG. Diagnostic triage for low back pain: a practical approach for primary care. Medical Journal of Australia. 2017;206(6):268-273. doi:10.5694/mja16.00828

Basse L, Thorbøl JE, Løssl K, Kehlet H. Colonic surgery with accelerated rehabilitation or conventional care. Dis Colon Rectum. 2004;47(3):271-277; discussion 277-278. doi:10.1007/s10350-003-0055-0

Beck AW, Simpson AK. High-Grade Lumbar Spondylolisthesis. Neurosurgery Clinics of North America. 2019;30(3):291-298. doi:10.1016/j.nec.2019.02.002

Blackburn, J., Madhaven, P., Leung, Y. L., and Walburn, M. An Enhanced Recovery Program for Elective Spinal Surgery Patients. Journal of Clinical Outcomes Management. 2016. 23 (10).

Bombard Y, Baker GR, Orlando E, et al. Engaging patients to improve quality of care: a systematic review. *Implementation Sci*. 2018;13(1):1-22. doi:10.1186/s13012-018-0784-z

Brady M, Kinn S, Stuart P. Preoperative fasting for adults to prevent perioperative complications. Cochrane Database Syst Rev. 2003;(4):CD004423. doi:10.1002/14651858.CD004423

Bradywood A, Farrokhi F, Williams B, Kowalczyk M, Blackmore CC. Reduction of Inpatient Hospital Length of Stay in Lumbar Fusion Patients With Implementation of an Evidence-Based Clinical Care Pathway. Spine. 2017;42(3):169-176. doi:10.1097/BRS.0000000000001703

Brett J, Staniszewska S, Mockford C, et al. Mapping the impact of patient and public involvement on health and social care research: a systematic review. Health Expect. 2014;17(5):637-650. doi:10.1111/j.1369-7625.2012.00795.x

Burgess LC, Arundel J, Wainwright TW. The Effect of Preoperative Education on Psychological, Clinical and Economic Outcomes in Elective Spinal Surgery: A Systematic Review. Healthcare (Basel). 2019 Mar 21;7(1):48

Calgary Spine Program [@CalgarySpine]. Congratulations to Dr. Michael Yang @MichaelYangMD and Dr. Ken Tomas who will be receiving 8.2 million dollars from the Calgary Health Foundation @yyc_health to build a Calgary Endoscopic Spine Surgery Program and an Enhanced Recovery After Surgery Program for Spine Surgery! 🙌 https://t.co/Yzz2O5H6AI. Twitter. Published March 15, 2024. Accessed April 17, 2024. https://twitter.com/CalgarySpine/status/1768657181660836012

Canadian Institutes of Health Research. Strategy for Patient Oriented Research. Patient engagement framework. Ottawa: CIHR 2014. Accessed October 6, 2024. Available: http://www.cihrirsc.gc.ca/e/documents/spor_framework-en.pdf.

Cerantola Y, Valerio M, Persson B, et al. Guidelines for perioperative care after radical cystectomy for bladder cancer: Enhanced Recovery After Surgery (ERAS(®)) society recommendations. Clin Nutr. 2013;32(6):879-887. doi:10.1016/j.clnu.2013.09.014

Chapman SJ, Helliwell JA, Lonsdale MDS, Tiernan JP, Jayne DG. Patient education about recovery after colorectal surgery: systematic scoping review. Colorectal Dis. 2020;22(12):1842-1849. doi:10.1111/codi.15337

Chen J, Li D, Wang R, et al. Benefits of the Enhanced Recovery After Surgery Program in Short-Segment Posterior Lumbar Interbody Fusion Surgery. World Neurosurgery. 2022;159:e303-e310. Doi:10.1016/j.wneu.2021.12.046

Chuang MF, Tung HH, Clinciu DL, et al. The effect of an integrated education model on anxiety and uncertainty in patients undergoing cervical disc herniation surgery. Computer Methods and Programs in Biomedicine. 2016;133:17-23. doi:10.1016/j.cmpb.2016.05.003

Cochrane Handbook for Systematic Reviews of Interventions. Accessed June 20, 2022. https://training.cochrane.org/handbook/current

Corniola MV, Meling TR, Tessitore E. Enhanced recovery after spine surgery-a multinational survey assessing surgeons' perspectives. Acta Neurochir (Wien). 2020;162(6):1371-1377. doi:10.1007/s00701-020-04293-x

CSORN. Participating Locations. Accessed March 22, 2024. https://www.csorncss.ca/about/participating-locations/

Cui P, Wang S, Wang P, Yang L, Kong C, Lu S. Comparison of perioperative outcomes in frail patients following multilevel lumbar fusion surgery with and without the implementation of the enhanced recovery after surgery protocol. Front Surg. 2022;9:997657. Doi:10.3389/fsurg.2022.997657

Daabiss M. American Society of Anaesthesiologists physical status classification. Indian J Anaesth. 2011;55(2):111-115. doi:10.4103/0019-5049.79879

d'Astorg H, Fière V, Dupasquier M, Vieira TD, Szadkowski M. Enhanced recovery after surgery (ERAS) protocol reduces LOS without additional adverse events in spine surgery. Orthopaedics & Traumatology: Surgery & Research. 2020;106(6):1167-1173. doi:10.1016/j.otsr.2020.01.017

Dagal., A., Bellabarba, C., Bransford, R., Zhang, F., Chesnut, R. M., O'Keefe, G. E., Wright, D. R., Dellit, T. H., Painter, I., and Souter, M. J. 2018. Enhanced Perioperative Care for Major Spine Surgery. Spine. DOI: 10.1097/BRS.0000000000002968

Davrieux CF, Palermo M, Serra E, et al. STAGES AND FACTORS OF THE "PERIOPERATIVE PROCESS": POINTS IN COMMON WITH THE AERONAUTICAL INDUSTRY. Arquivos Brasileiros de Cirurgia Digestiva : ABCD. 2019;32(1). doi:10.1590/0102-672020180001e1423

Davy TA, Sharp C, Lynch S. Perioperative pain control. Clin Podiatr Med Surg. 2003;20(2):257-267. doi:10.1016/S0891-8422(03)00006-5

De Biase G, Carter RE, Otamendi-Lopez A, et al. Assessment of surgeons' attitude towards awake spine surgery under spinal anesthesia. J Clin Neurosci. 2023;107:48-53. doi:10.1016/j.jocn.2022.12.003

Debono B, Corniola MV, Pietton R, Sabatier P, Hamel O, Tessitore E. Benefits of Enhanced Recovery After Surgery for fusion in degenerative spine surgery: impact on outcome, length of stay, and patient satisfaction. Neurosurgical Focus. 2019;46(4):E6. doi:10.3171/2019.1.FOCUS18669

a. Debono B, Wainwright TW, Wang MY, et al. Consensus statement for perioperative care in lumbar spinal fusion: Enhanced Recovery After Surgery (ERAS®) Society recommendations. The Spine Journal. 2021;21(5):729-752. doi:10.1016/j.spinee.2021.01.001

b. Debono B, Sabatier P, Boniface G, et al. Implementation of enhanced recovery after surgery (ERAS) protocol for anterior cervical discectomy and fusion: a propensity score-matched analysis. Eur Spine J. 2021;30(2):560-567. doi:10.1007/s00586-020-06445-0

Deer T, Sayed D, Michels J, Josephson Y, Li S, Calodney AK. A Review of Lumbar Spinal Stenosis with Intermittent Neurogenic Claudication: Disease and Diagnosis. Pain Med. 2019;20(Suppl 2):S32-S44. doi:10.1093/pm/pnz161

Di Capua J, Somani S, Kim JS, et al. Predictors for Patient Discharge Destination After Elective Anterior Cervical Discectomy and Fusion. Spine. 2017;42(20):1538. doi:10.1097/BRS.0000000000002140

Dietz N, Sharma M, Adams S, et al. Enhanced Recovery After Surgery (ERAS) for Spine Surgery: A Systematic Review. World Neurosurg. 2019;130:415-426. doi:10.1016/j.wneu.2019.06.181

Domecq JP, Prutsky G, Elraiyah T, et al. Patient engagement in research: a systematic review. BMC Health Serv Res. 2014;14:89. doi:10.1186/1472-6963-14-89

Doria N, Condran B, Boulos L, Curtis Maillet DG, Dowling L, Levy A. Sharpening the focus: differentiating between focus groups for patient engagement vs. qualitative research. Res Involv Engagem. 2018;4:19. doi:10.1186/s40900-018-0102-6

Du X, Ou Y, Jiang G, Luo W, Jiang D. Chewing gum promotes bowel function recovery in elderly patients after lumbar spinal surgery: a retrospective single-center cohort study. Ann Palliat Med. 2021;10(2):1216-1223. doi:10.21037/apm-20-1077

Duojun W, Hui Z, Zaijun L, Yuxiang G, Haihong C. Enhanced recovery after surgery pathway reduces the length of hospital stay without additional complications in lumbar disc herniation treated by percutaneous endoscopic transforaminal discectomy. Journal of Orthopaedic Surgery & Research. 2021;16(1):1-8. doi:10.1186/s13018-021-02606-z

Dydyk AM, Ngnitewe Massa R, Mesfin FB. Disc Herniation. In: StatPearls. StatPearls Publishing; 2024. Accessed April 11, 2024. http://www.ncbi.nlm.nih.gov/books/NBK441822/

Elias KM, Stone AB, McGinigle K, et al. The Reporting on ERAS Compliance, Outcomes, and Elements Research (RECOvER) Checklist: A Joint Statement by the

ERAS® and ERAS® USA Societies. *World J Surg*. 2019;43(1):1-8. doi:10.1007/s00268-018-4753-0

Elsarrag M, Soldozy S, Patel P, et al. Enhanced recovery after spine surgery: a systematic review. Neurosurg Focus. 2019;46(4):E3. doi:10.3171/2019.1.FOCUS18700

Epstein NE. Case presentation and short perspective on management of foraminal/far lateral discs and stenosis. Surg Neurol Int. 2018;9:87. doi:10.4103/sni.sni_66_18

ERAS® Society. Guidelines. Accessed September 6, 2024. https://erassociety.org/guidelines/

Esmail L, Moore E, Rein A. Evaluating patient and stakeholder engagement in research: moving from theory to practice. J Comp Eff Res. 2015;4(2):133-145. doi:10.2217/cer.14.79

Evans, S., Myers, E. M., and Vilasagar, S. 2019. Patient perceptions of same-day discharge after minimally invasive gynecologic and pelvic reconstructive surgery. American Journal of Obstetrics and Gynecology. DOI: https://doi.org/10.1016/j.ajog.2019.06.046

Farag E, Ghobrial M, Sessler DI, et al. Effect of perioperative intravenous lidocaine administration on pain, opioid consumption, and quality of life after complex spine surgery. Anesthesiology. 2013;119(4):932-940. doi:10.1097/ALN.0b013e318297d4a5

Fan S, Hu Z, Zhao F, Zhao X, Huang Y, Fang X. Multifidus muscle changes and clinical effects of one-level posterior lumbar interbody fusion: minimally invasive procedure

versus conventional open approach. Eur Spine J. 2010;19(2):316-324. doi:10.1007/s00586-009-1191-6

Fearon KCH, Ljungqvist O, Von Meyenfeldt M, et al. Enhanced recovery after surgery: A consensus review of clinical care for patients undergoing colonic resection. Clinical Nutrition. 2005;24(3):466-477. doi:10.1016/j.clnu.2005.02.002

Fjeld OR, Grøvle L, Helgeland J, et al. Complications, reoperations, readmissions, and length of hospital stay in 34 639 surgical cases of lumbar disc herniation. Bone Joint J. 2019;101-B(4):470-477. doi:10.1302/0301-620X.101B4.BJJ-2018-1184.R1

Fiani B, Quadri SA, Farooqui M, et al. Impact of robot-assisted spine surgery on health care quality and neurosurgical economics: A systemic review. Neurosurg Rev. 2020;43(1):17-25. doi:10.1007/s10143-018-0971-z

Flanders TM, Ifrach J, Sinha S, et al. Reduction of Postoperative Opioid Use After Elective Spine and Peripheral Nerve Surgery Using an Enhanced Recovery After Surgery Program. Pain Medicine. 2020;21(12):3283-3291. doi:10.1093/pm/pnaa233

Flippin MA. Cervical myelopathy. Orthopedics. 2013;36(9):697-698. doi:10.3928/01477447-20130821-05

Foley KT, Smith MM, Rampersaud YR. Microendoscopic approach to far-lateral lumbar disc herniation. Neurosurg Focus. 1999;7(5):e5. doi:10.3171/foc.1999.7.6.6

Forsmo HM, Pfeffer F, Rasdal A, Sintonen H, Körner H, Erichsen C. Pre- and postoperative stoma education and guidance within an enhanced recovery after surgery

(ERAS) programme reduces length of hospital stay in colorectal surgery. International Journal of Surgery. 2016;36:121-126. doi:10.1016/j.ijsu.2016.10.031

Forsythe LP, Ellis LE, Edmundson L, et al. Patient and Stakeholder Engagement in the PCORI Pilot Projects: Description and Lessons Learned. *J Gen Intern Med*. 2016;31(1):13-21. doi:10.1007/s11606-015-3450-z

Forsythe L, Heckert A, Margolis MK, Schrandt S, Frank L. Methods and impact of engagement in research, from theory to practice and back again: early findings from the Patient-Centered Outcomes Research Institute. *Qual Life Res*. 2018;27(1):17-31. doi:10.1007/s11136-017-1581-x

Forsythe LP, Carman KL, Szydlowski V, et al. Patient Engagement In Research: Early Findings From The Patient- Centered Outcomes Research Institute. Health Affairs. 2019;38(3):359-367,367A. doi:10.1377/hlthaff.2018.05067

Freda MC. Issues in patient education. Journal of Midwifery & Women's Health. 2004;49(3):203-209. doi:10.1016/j.jmwh.2004.01.003

Furtado R, MacDermid JC, Ziebart C, Bryant D, Faber KJ. Preoperative Patient Education Programs for Orthopaedic Surgery: What Do the Programs Include? How Are They Delivered? What Are the Knowledge Gaps? A Scoping Review of 46 Studies. J Orthop Sports Phys Ther. 2022;52(9):572-585. doi:10.2519/jospt.2022.10614

Gadjradj PS, Basilious M, Goldberg JL, et al. Decompression alone versus decompression with fusion in patients with lumbar spinal stenosis with degenerative

spondylolisthesis: a systematic review and meta-analysis. Eur Spine J. 2023;32(3):1054-1067. doi:10.1007/s00586-022-07507-1

Garg B, Mehta N, Bansal T, Shekhar S, Khanna P, Baidya DK. Design and Implementation of an Enhanced Recovery After Surgery Protocol in Elective Lumbar Spine Fusion by Posterior Approach: A Retrospective, Comparative Study. Spine (03622436). 2021;46(12):E679-E687. doi:10.1097/BRS.0000000000003869

Gale, J., Thompson, C., Lortie, K. J., Bougie, O., and Singh, S. S. 2018. Early Discharge after Laparoscopic Hysterectomy: a Prospective Study. Journal of Obstetrics and Gynaecology Canada. 40(9):1154-1161.

Geere JH, Swamy GN, Hunter PR, et al. Incidence and risk factors for five-year recurrent disc herniation after primary single-level lumbar discectomy: analysis of 733 patients. The Bone & Joint Journal. 2023;105-B(3):315-322. doi:10.1302/0301-620X.105B3.BJJ-2022-1005.R2

Ghogawala Z, Dziura J, Butler WE, et al. Laminectomy plus Fusion versus Laminectomy Alone for Lumbar Spondylolisthesis. N Engl J Med. 2016;374(15):1424-1434. doi:10.1056/NEJMoa1508788

Golan JD, Elkaim LM, Alrashidi Q, Georgiopoulos M, Lasry O. Economic comparisons of endoscopic spine surgery: a systematic review. Eur Spine J. 2023;32(8):2627-2636. doi:10.1007/s00586-023-07699-0

Goldberg JL, Härtl R, Elowitz E. Minimally Invasive Spine Surgery: An Overview. World Neurosurgery. 2022;163:214-227. doi:10.1016/j.wneu.2022.03.114

Gotlib Conn L, McKenzie M, Pearsall EA, McLeod RS. Successful implementation of an enhanced recovery after surgery programme for elective colorectal surgery: a process evaluation of champions' experiences. Implementation Sci. 2015;10(1):1-11. doi:10.1186/s13012-015-0289-y

Golubovsky JL, Ilyas H, Chen J, Tanenbaum JE, Mroz TE, Steinmetz MP. Risk factors and associated complications for postoperative urinary retention after lumbar surgery for lumbar spinal stenosis. The Spine Journal. 2018;18(9):1533-1539. doi:10.1016/j.spinee.2018.01.022

Goz V, Weinreb JH, McCarthy I, Schwab F, Lafage V, Errico TJ. Perioperative complications and mortality after spinal fusions: analysis of trends and risk factors. Spine (Phila Pa 1976). 2013;38(22):1970-1976. doi:10.1097/BRS.0b013e3182a62527

GRADE handbook. Accessed June 20, 2022. https://gdt.gradepro.org/app/handbook/handbook.html

Graffigna G, Barello S. Patient Health Engagement (PHE) model in enhanced recovery after surgery (ERAS): monitoring patients' engagement and psychological resilience in minimally invasive thoracic surgery. J Thorac Dis. 2018;10(Suppl 4):S517-S528. doi:10.21037/jtd.2017.12.84

Grasu RM, Cata JP, Dang AQ, et al. Implementation of an Enhanced Recovery After Spine Surgery program at a large cancer center: a preliminary analysis. Published online November 1, 2018. doi:10.3171/2018.4.SPINE171317

Greenberg MS. Handbook of Neurosurgery: 8th Edition. 2016. Thieme. Thieme Medical Publishers, Inc. New York, NY, USA. Pages 1037, 1072, and 1079.

Gustafsson UO, Scott MJ, Hubner M, et al. Guidelines for Perioperative Care in Elective Colorectal Surgery: Enhanced Recovery After Surgery (ERAS®) Society Recommendations: 2018. World J Surg. 2019;43(3):659-695. doi:10.1007/s00268-018-4844-y

Hasan S, Hofstetter CP. Endoscopic Spine Surgery: Past, Present, and Future. Bulletin of the Hospital for Joint Diseases. 2019;77(1):75-84.

Heathcote S Sr, Duggan K, Rosbrugh J, et al. Enhanced Recovery after Surgery (ERAS) Protocols Expanded over Multiple Service Lines Improves Patient Care and Hospital Cost. Am Surg. 2019;85(9):1044-1050.

Heisinger S, Huber D, Matzner MP, et al. TLIF Online Videos for Patient Education—Evaluation of Comprehensiveness, Quality, and Reliability. Int J Environ Res Public Health. 2023;20(5):4626. doi:10.3390/ijerph20054626

Heo DH, Ha Y, Yi S, Chung H. The Future of Minimally Invasive Spine Surgery. Neurol India. 2022;70(Supplement):S104-S107. doi:10.4103/0028-3886.360930

Hermann PC, Webler M, Bornemann R, et al. Influence of smoking on spinal fusion after spondylodesis surgery: A comparative clinical study. Technol Health Care. 2016;24(5):737-744. doi:10.3233/THC-161164

Higgins JPT, Thompson SG, Deeks JJ, Altman DG. Measuring inconsistency in meta-analyses. BMJ. 2003;327(7414):557-560.

Home. ERAS® Society. Accessed January 23, 2024. https://erassociety.org/

Huang J, Shi Z, Duan F, et al. Benefits of Early Ambulation in Elderly Patients Undergoing Lumbar Decompression and Fusion Surgery: A Prospective Cohort Study. Orthop Surg. 2021;13(4):1319-1326. doi:10.1111/os.12953

Husted, H., Lunn, T., H., Troelsen, A., Gaarn-Larsen, L., Kristensen, B. B., and Kehlet, H. 2011. Why still in hospital after fast-track hip and knee arthroplasty?. Acta Orthopaedica. 82(6): 679-684.

Issack PS, Cunningham ME, Pumberger M, Hughes AP, Cammisa FPJ. Degenerative Lumbar Spinal Stenosis: Evaluation and Management. JAAOS - Journal of the American Academy of Orthopaedic Surgeons. 2012;20(8):527. doi:10.5435/JAAOS-20-08-527

Ivynian SE, Newton PJ, DiGiacomo M. Patient preferences for heart failure education and perceptions of patient-provider communication. Scand J Caring Sci. 2020;34(4):1094-1101. doi:10.1111/scs.12820

Jain SN, Lamture Y, Krishna M. Enhanced Recovery After Surgery: Exploring the Advances and Strategies. Cureus. 2023;15(10):e47237. doi:10.7759/cureus.47237

Jakobsen DH, Sonne E, Andreasen J, Kehlet H. Convalescence after colonic surgery with fast-track vs conventional care. Colorectal Dis. 2006;8(8):683-687. doi:10.1111/j.1463-1318.2006.00995.x

Javidan A, Vignarajah M, Nelms MW, et al. YouTube as a Source of Patient and Trainee Education in Vascular Surgery: A Systematic Review. EJVES Vasc Forum. 2024;61:62-76. doi:10.1016/j.ejvsvf.2024.01.054

Jonsson, A., Lin, E., Patel, L., Patel, A. D., Stetler, J. L., Prayor-Patterson, H., Singh, A., Srinivasan, J. K., Sweeney, J. F., and Davis Jr., S. S. 2018. Barriers to Enhanced Recovery after Surgery after Laparoscopic Sleeve Gastrectomy. Journal of the American College of Surgeons. 226(4): 605-613.

Joseph JR, Smith BW, Liu X, Park P. Current applications of robotics in spine surgery: a systematic review of the literature. Neurosurg Focus. 2017;42(5):E2. doi:10.3171/2017.2.FOCUS16544

a. Kalichman L, Cole R, Kim DH, et al. Spinal stenosis prevalence and association with symptoms: the Framingham Study. Spine J. 2009;9(7):545-550. doi:10.1016/j.spinee.2009.03.005

b. Kalichman L, Kim DH, Li L, Guermazi A, Berkin V, Hunter DJ. Spondylolysis and spondylolisthesis: prevalence and association with low back pain in the adult community-based population. Spine (Phila Pa 1976). 2009;34(2):199-205. doi:10.1097/BRS.0b013e31818edcfd

Karlsson T, Försth P, Skorpil M, et al. Decompression alone or decompression with fusion for lumbar spinal stenosis: a randomized clinical trial with two-year MRI follow-up. Bone Joint J. 2022;104-B(12):1343-1351. doi:10.1302/0301-620X.104B12.BJJ-2022-0340.R1

Kehlet H, Mogensen T. Hospital stay of 2 days after open sigmoidectomy with a multimodal rehabilitation programme. British Journal of Surgery. 1999;86(2):227-230. doi:10.1046/j.1365-2168.1999.01023.x

Kehlet H, Wilmore DW. Multimodal strategies to improve surgical outcome. Am J Surg. 2002;183(6):630-641. doi:10.1016/s0002-9610(02)00866-8

Kehlet H. Enhanced postoperative recovery: good from afar, but far from good? Anaesthesia. 2020;75(S1):e54-e61. doi:10.1111/anae.14860

Kehlet H, Dahl JB. Anaesthesia, surgery, and challenges in postoperative recovery. Lancet. 2003;362(9399):1921-1928. doi:10.1016/S0140-6736(03)14966-5

Kehlet H. Fast-track colorectal surgery. Lancet. 2008;371(9615):791-793. doi:10.1016/S0140-6736(08)60357-8

Kehlet H, Wilmore DW. Evidence-based surgical care and the evolution of fast-track surgery. Ann Surg. 2008;248(2):189-198. doi:10.1097/SLA.0b013e31817f2c1a

Kehlet H. Enhanced postoperative recovery: good from afar, but far from good? Anaesthesia. 2020;75(S1):e54-e61. doi:10.1111/anae.14860

Kerolus MG, Yerneni K, Witiw CD, et al. Enhanced Recovery After Surgery Pathway for Single-Level Minimally Invasive Transforaminal Lumbar Interbody Fusion Decreases Length of Stay and Opioid Consumption. Neurosurgery. 2021;88(3):648-657. doi:10.1093/neuros/nyaa493

Kesänen J, Leino-Kilpi H, Lund T, Montin L, Puukka P, Valkeapää K. The Knowledge Test Feedback Intervention (KTFI) increases knowledge level of spinal stenosis patients before operation-A randomized controlled follow-up trial. Patient Educ Couns. 2016;99(12):1984-1991. doi:10.1016/j.pec.2016.07.025

Kesänen J, Leino-Kilpi H, Lund T, Montin L, Puukka P, Valkeapää K. Increased preoperative knowledge reduces surgery-related anxiety: a randomised clinical trial in 100 spinal stenosis patients. Eur Spine J. 2017;26(10):2520-2528. doi:10.1007/s00586-017-4963-4

Khoo CK, Vickery CJ, Forsyth N, Vinall NS, Eyre-Brook IA. A Prospective Randomized Controlled Trial of Multimodal Perioperative Management Protocol in Patients Undergoing Elective Colorectal Resection for Cancer. Annals of Surgery. 2007;245(6):867. doi:10.1097/01.sla.0000259219.08209.36

Kim HJ, Jung WI, Chang BS, Lee CK, Kang KT, Yeom JS. A prospective, randomized, controlled trial of robot-assisted vs freehand pedicle screw fixation in spine surgery. Int J Med Robot. 2017;13(3). doi:10.1002/rcs.1779

Koes BW, van Tulder M, Lin CWC, Macedo LG, McAuley J, Maher C. An updated overview of clinical guidelines for the management of non-specific low back pain in primary care. Eur Spine J. 2010;19(12):2075-2094. doi:10.1007/s00586-010-1502-y

Kong CB, Jeon DW, Chang BS, Lee JH, Suk KS, Park JB. Outcome of spinal fusion for lumbar degenerative disease: a cross-sectional study in Korea. Spine (Phila Pa 1976). 2010;35(15):1489-1494. doi:10.1097/BRS.0b013e3181c49fd0

Kurtović B, Rotim K, Mladić Batinica I, Milošević M, Božić B, Kalauz S. Analgesic Effect - Comparison of Paracetamol Administered Intermittently and Through Patient-Controlled Analgesia Pump after Lumbar Discectomy: a Prospective Clinical Study. Acta Clin Croat. 2017;56(2):236-243. doi:10.20471/acc.2017.56.02.06

Landers MR, Puentedura E, Louw A, McCauley A, Rasmussen Z, Bungum T. A Population-Based Survey of Lumbar Surgery Beliefs in the United States. Orthopaedic Nursing. 2014;33(4):207. doi:10.1097/NOR.0000000000000064

Lee CH, Liu JT, Lin SC, Hsu TY, Lin CY, Lin LY. Effects of Educational Intervention on State Anxiety and Pain in People Undergoing Spinal Surgery: A Randomized Controlled Trial. Pain Manag Nurs. 2018;19(2):163-171. doi:10.1016/j.pmn.2017.08.004

Leitner L, Wanivenhaus F, Bachmann LM, et al. Bladder management in patients undergoing spine surgery: An assessment of care delivery. N Am Spine Soc J. 2021;6:100059. doi:10.1016/j.xnsj.2021.100059

Li J, Li H, Xv Z, et al. Enhanced recovery care versus traditional care following laminoplasty. Medicine (Baltimore). 2018;97(48):e13195. doi:10.1097/MD.0000000000013195

Li ZE, Lu SB, Kong C, Sun WZ, Wang P, Zhang ST. Comparative short-term outcomes of enhanced recovery after surgery (ERAS) program and non-ERAS traditional care in elderly patients undergoing lumbar arthrodesis: a retrospective study. BMC Musculoskeletal Disorders. 2021;22(1):1-10. doi:10.1186/s12891-021-04166-z

Lindley EM, Milligan K, Farmer R, Burger EL, Patel VV. Patient-Controlled Transdermal Fentanyl Versus Intravenous Morphine Pump After Spine Surgery. Orthopedics. 2015;38(9):e819-824. doi:10.3928/01477447-20150902-61

Ljungqvist O. Jonathan E. Rhoads lecture 2011: Insulin resistance and enhanced recovery after surgery. JPEN J Parenter Enteral Nutr. 2012;36(4):389-398. doi:10.1177/0148607112445580

Ljungqvist O. ERAS—Enhanced Recovery After Surgery. Journal of Parenteral and Enteral Nutrition. 2014;38(5):559-566. doi:10.1177/0148607114523451

Ljungqvist O, Scott M, Fearon KC. Enhanced Recovery After Surgery: A Review. JAMA Surgery. 2017;152(3):292-298. doi:10.1001/jamasurg.2016.4952

Long WW, Modi KD, Haws BE, et al. Assessing Online Patient Education Readability for Spine Surgery Procedures. Clinical Spine Surgery. 2018;31(2):E146. doi:10.1097/BSD.0000000000000575

Lonjon G, Boutron I, Trinquart L, et al. Comparison of Treatment Effect Estimates From Prospective Nonrandomized Studies With Propensity Score Analysis and Randomized Controlled Trials of Surgical Procedures. Annals of Surgery. 2014;259(1):18-25. doi:10.1097/SLA.0000000000000256

Louw A, Diener I, Butler DS, Puentedura EJ. Preoperative education addressing postoperative pain in total joint arthroplasty: review of content and educational delivery methods. Physiother Theory Pract. 2013;29(3):175-194. doi:10.3109/09593985.2012.727527

Louw A, Diener I, Landers MR, Zimney K, Puentedura EJ. Three-year follow-up of a randomized controlled trial comparing preoperative neuroscience education for patients

undergoing surgery for lumbar radiculopathy. J Spine Surg. 2016;2(4):289-298. doi:10.21037/jss.2016.12.04

Luciani AM, Foster BK, Hayes D, DelSole EM. Readability of Online Spine Patient Education Resources. World Neurosurgery. 2022;162:e640-e644. doi:10.1016/j.wneu.2022.03.091

Lurie J, Tomkins-Lane C. Management of lumbar spinal stenosis. BMJ. 2016;352:h6234. doi:10.1136/bmj.h6234

Macki M, Zakaria HM, Massie LW, et al. The Effect of Physical Therapy on Time to Discharge After Lumbar Interbody Fusion. Clinical Neurology and Neurosurgery. 2020;197:106157. doi:10.1016/j.clineuro.2020.106157

Maessen J, Dejong CHC, Hausel J, et al. A protocol is not enough to implement an enhanced recovery programme for colorectal resection. British Journal of Surgery. 2007;94(2):224-231. doi:10.1002/bjs.5468

Mathew PJ, Jehan F, Kulvatunyou N, et al. The burden of excess length of stay in trauma patients. Am J Surg. 2018;216(5):881-885. doi:10.1016/j.amjsurg.2018.07.044

Mathiesen O, Dahl B, Thomsen BA, et al. A comprehensive multimodal pain treatment reduces opioid consumption after multilevel spine surgery. Eur Spine J. 2013;22(9):2089-2096. doi:10.1007/s00586-013-2826-1

Maurer M, Mangrum R, Hilliard-Boone T, et al. Understanding the Influence and Impact of Stakeholder Engagement in Patient-centered Outcomes Research: a Qualitative Study. J Gen Intern Med. 2022;37(Suppl 1):6-13. doi:10.1007/s11606-021-07104-w

McDonald IR, Blocker ES, Weyman EA, Smith N, Dwyer AA. What Are the Best Practices for Co-Creating Patient-Facing Educational Materials? A Scoping Review of the Literature. Healthcare (Basel). 2023;11(19):2615. doi:10.3390/healthcare11192615

McDonald S, Page MJ, Beringer K, Wasiak J, Sprowson A. Preoperative education for hip or knee replacement. Cochrane Database Syst Rev. 2014;2014(5):CD003526. doi:10.1002/14651858.CD003526.pub3

McDonnell JM, Ahern DP, Ó Doinn T, et al. Surgeon proficiency in robot-assisted spine surgery. Bone Joint J. 2020;102-B(5):568-572. doi:10.1302/0301-620X.102B5.BJJ-2019-1392.R2

McMullen CA, Williams MV, Smyth SS, Clouser JM, Li J. Co-designing and piloting educational materials with patients and healthcare providers for syncope in the emergency department. PEC Innovation. 2023;2:100131. doi:10.1016/j.pecinn.2023.100131

Meyrat R, Vivian E, Sridhar A, et al. Development of multidisciplinary, evidenced-based protocol recommendations and implementation strategies for anterior lumbar interbody fusion surgery following a literature review. Medicine (Baltimore). 2023;102(47):e36142. doi:10.1097/MD.0000000000036142

Mino DE, Munterich JE, Castel LD. Lumbar fusion surgery for degenerative conditions is associated with significant resource and narcotic use 2 years postoperatively in the commercially insured: a medical and pharmacy claims study. Journal of Spine Surgery. 2017;3(2):141-148. doi:10.21037/jss.2017.04.02

Mobbs RJ, Phan K, Malham G, Seex K, Rao PJ. Lumbar interbody fusion: techniques, indications and comparison of interbody fusion options including PLIF, TLIF, MI-TLIF, OLIF/ATP, LLIF and ALIF. J Spine Surg. 2015;1(1):2-18. doi:10.3978/j.issn.2414-469X.2015.10.05

Nelson G, Bakkum-Gamez J, Kalogera E, et al. Guidelines for perioperative care in gynecologic/oncology: Enhanced Recovery After Surgery (ERAS) Society recommendations—2019 update. International Journal of Gynecologic Cancer. Published online March 15, 2019:ijgc. doi:10.1136/ijgc-2019-000356

Noblett SE, Watson DS, Huong H, Davison B, Hainsworth PJ, Horgan AF. Pre-operative oral carbohydrate loading in colorectal surgery: a randomized controlled trial. Colorectal Dis. 2006;8(7):563-569. doi:10.1111/j.1463-1318.2006.00965.x

Nygren J, Thorell A, Ljungqvist O. Preoperative oral carbohydrate therapy. Curr Opin Anaesthesiol. 2015;28(3):364-369. doi:10.1097/ACO.0000000000000192

O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. Standards for reporting qualitative research: a synthesis of recommendations. Acad Med. 2014;89(9):1245-1251. doi:10.1097/ACM.0000000000000388

Ogrinc G, Davies L, Goodman D, Batalden P, Davidoff F, Stevens D. SQUIRE 2.0 (Standards for QUality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. BMJ Qual Saf. 2016;25(12):986-992. doi:10.1136/bmjqs-2015-004411

Ogura Y, Gum JL, Steele P, et al. Multi-modal pain control regimen for anterior lumbar fusion drastically reduces in-hospital opioid consumption. J Spine Surg. 2020;6(4):681-687. doi:10.21037/jss-20-629

Overview | Lateral interbody fusion in the lumbar spine for low back pain | Guidance | NICE. Published February 22, 2017. Accessed April 11, 2024. https://www.nice.org.uk/guidance/ipg574

Papanastassiou I, Anderson R, Barber N, Conover C, Castellvi AE. Effects of preoperative education on spinal surgery patients. SAS J. 2011;5(4):120-124. doi:10.1016/j.esas.2011.06.003

Parisi A, Desiderio J, Cirocchi R, Trastulli S. Enhanced Recovery after Surgery (ERAS): a Systematic Review of Randomised Controlled Trials (RCTs) in Bariatric Surgery. Obes Surg. 2020;30(12):5071-5085. doi:10.1007/s11695-020-05000-6

Passias PG, Bortz C, Alas H, et al. Alcoholism as a predictor for pseudarthrosis in primary spine fusion: An analysis of risk factors and 30-day outcomes for 52,402 patients from 2005 to 2013. Journal of Orthopaedics. 2019;16(1):36-40. doi:10.1016/j.jor.2018.12.011

Patel PD, Canseco JA, Houlihan N, Gabay A, Grasso G, Vaccaro AR. Overview of Minimally Invasive Spine Surgery. World Neurosurgery. 2020;142:43-56. doi:10.1016/j.wneu.2020.06.043

Pearsall EA, McLeod RS. Enhanced Recovery After Surgery: Implementation Strategies, Barriers and Facilitators. Surgical Clinics of North America. 2018;98(6):1201-1210. doi:10.1016/j.suc.2018.07.007

Pennington Z, Cottrill E, Lubelski D, Ehresman J, Theodore N, Sciubba DM. Systematic review and meta-analysis of the clinical utility of Enhanced Recovery After Surgery pathways in adult spine surgery. J Neurosurg Spine. Published online November 6, 2020:1-23. doi:10.3171/2020.6.SPINE20795

Peres-da-Silva A, Kleeman LT, Wellman SS, et al. What Factors Drive Inpatient Satisfaction After Knee Arthroplasty? The Journal of Arthroplasty. 2017;32(6):1769-1772. doi:10.1016/j.arth.2017.01.036

Pertsch NJ, Darveau SC, Tang OY, Toms SA, Weil RJ. Urinary Tract Infection after Elective Spine Surgery: Timing, Predictive Factors, and Outcomes. *Spine*. 2021;46(5):337. doi:10.1097/BRS.0000000000003794

Pokorny G, Amaral R, Marcelino F, et al. Minimally invasive versus open surgery for degenerative lumbar pathologies:a systematic review and meta-analysis. Eur Spine J. 2022;31(10):2502-2526. doi:10.1007/s00586-022-07327-3

Porche 2023: Porche K, Yan SC, Mehkri Y, et al. The Enhanced Recovery After Surgery pathway for posterior cervical surgery: a retrospective propensity-matched cohort study. Journal of Neurosurgery: Spine. Published online April 1, 2023:1-12. doi:10.3171/2023.2.SPINE221174

Rajjoub R, Ghaith AK, El-Hajj VG, et al. Comparative outcomes of awake spine surgery under spinal versus general anesthesia: a comprehensive systematic review and meta-analysis. Eur Spine J. Published online December 19, 2023. doi:10.1007/s00586-023-08071-y

Reeves BC, Deeks JJ, Higgins JPT, Shea B, Tugwell P, Wells GA. Chapter 24: Including non-randomized studies on intervention effects [last updated October 2019]. In: Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA (editors). Cochrane Handbook for Systematic Reviews of Interventions version 6.5. Cochrane, 2024. Available from www.training.cochrane.org/handbook.

Reiter K. A look at best practices for patient education in outpatient spine surgery. AORN J. 2014;99(3):376-384. doi:10.1016/j.aorn.2014.01.008

Richards T. Patient and public involvement in research goes global. The BMJ. November 30, 2017. Accessed October 6, 2024. https://blogs.bmj.com/bmj/2017/11/30/tessa-richards-patient-and-public-involvement-in-research-goes-global/

Riga M, Altsitzioglou P, Saranteas T, Mavrogenis AF. Enhanced recovery after surgery (ERAS) protocols for total joint replacement surgery. SICOT J. 2023;9:E1. doi:10.1051/sicotj/2023030

Safa A, De Biase G, Gassie K, Garcia D, Abode-Iyamah K, Chen SG. Reliability of YouTube videos on robotic spine surgery for patient education. J Clin Neurosci. 2023;109:6-10. doi:10.1016/j.jocn.2022.12.014

Sauro KM, Smith C, Ibadin S, Thomas A, Ganshorn H, Bakunda L, Bajgain B, Bisch SP, Nelson G. Enhanced Recovery After Surgery Guidelines and Hospital Length of Stay, Readmission, Complications, and Mortality: A Meta-Analysis of Randomized Clinical Trials. JAMA Netw Open. 2024 Jun 3;7(6):e2417310

Schoenfeld AJ, Weiner BK. Treatment of lumbar disc herniation: Evidence-based practice. Int J Gen Med. 2010;3:209-214.

Schünemann HJ, Cuello C, Akl EA, et al. GRADE Guidelines: 18. How ROBINS-I and other tools to assess risk of bias in non-randomized studies should be used to rate the certainty of a body of evidence. J Clin Epidemiol. 2019;111:105-114. doi:10.1016/j.jclinepi.2018.01.012

Selva-Sevilla C, Ferrara P, Gerónimo-Pardo M. Cost-utility Analysis for Recurrent Lumbar Disc Herniation: Conservative Treatment Versus Discectomy Versus Discectomy With Fusion. Clin Spine Surg. 2019;32(5):E228-E234. doi:10.1097/BSD.0000000000000797

Shamseer L, Moher D, Clarke M, et al. Preferred reporting items for systematic review and meta-analysis protocols (PRISMA-P) 2015: elaboration and explanation. BMJ. 2015;349:g7647. doi:10.1136/bmj.g7647

Shippee ND, Domecq Garces JP, Prutsky Lopez GJ, et al. Patient and service user engagement in research: a systematic review and synthesized framework. Health Expect. 2015;18(5):1151-1166. doi:10.1111/hex.12090

Skivington K, Matthews L, Simpson SA, et al. A new framework for developing and evaluating complex interventions: update of Medical Research Council guidance. BMJ. 2021;374:n2061. doi:10.1136/bmj.n2061

Smith J, Probst S, Calandra C, et al. Enhanced recovery after surgery (ERAS) program for lumbar spine fusion. Perioper Med (Lond). 2019;8:4. doi:10.1186/s13741-019-0114-2

Soffin EM, Wetmore DS, Barber LA, et al. An enhanced recovery after surgery pathway: association with rapid discharge and minimal complications after anterior cervical spine surgery. Neurosurg Focus. 2019;46(4):E9. doi:10.3171/2019.1.FOCUS18643

Staartjes VE, de Wispelaere MP, Schröder ML. Improving recovery after elective degenerative spine surgery: 5-year experience with an enhanced recovery after surgery (ERAS) protocol. Neurosurg Focus. 2019;46(4):E7. doi:10.3171/2019.1.FOCUS18646

Staniszewska S, Brett J, Simera I, et al. GRIPP2 reporting checklists: tools to improve reporting of patient and public involvement in research. BMJ. 2017;358:j3453. doi:10.1136/bmj.j3453

Sterne JA, Hernán MA, Reeves BC, et al. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ. 2016;355:i4919. doi:10.1136/bmj.i4919

The EQUATOR Network | Enhancing the QUAlity and Transparency Of Health Research. Accessed July 18, 2022. https://www.equator-network.org/

Tong Y, Fernandez L, Bendo JA, Spivak JM. Enhanced Recovery After Surgery Trends in Adult Spine Surgery: A Systematic Review. Int J Spine Surg. 2020;14(4):623-640. doi:10.14444/7083

Vancouver Spine Surgery Institute. Patient Information. Accessed October 8, 2024. https://vancouverspinesurgery.com/patient-information/

Vandenbroucke JP, von Elm E, Altman DG, et al. Strengthening the Reporting of Observational Studies in Epidemiology (STROBE): explanation and elaboration. PLoS Med. 2007;4(10):e297. doi:10.1371/journal.pmed.0040297

Wainwright TW, Immins T, Middleton RG. Enhanced recovery after surgery (ERAS) and its applicability for major spine surgery. Best Pract Res Clin Anaesthesiol. 2016;30(1):91-102. doi:10.1016/j.bpa.2015.11.001

Wainwright TW, Gill M, McDonald DA, et al. Consensus statement for perioperative care in total hip replacement and total knee replacement surgery: Enhanced Recovery After Surgery (ERAS®) Society recommendations. Acta Orthop. 2020;91(1):3-19. doi:10.1080/17453674.2019.1683790

Walker CT, Gullotti DM, Prendergast V, et al. Implementation of a Standardized Multimodal Postoperative Analgesia Protocol Improves Pain Control, Reduces Opioid Consumption, and Shortens Length of Hospital Stay After Posterior Lumbar Spinal Fusion. Neurosurgery. 2020;87(1):130-136. doi:10.1093/neuros/nyz312

Wang 2022a: Wang W, Wang P, Kong C, et al. Retrospective Data Analysis for Enhanced Recovery After Surgery (ERAS) Protocol for Elderly Patients with Long-Level Lumbar Fusion. World Neurosurgery. 2022;164:e397-e403. doi:10.1016/j.wneu.2022.04.109

Wang 2022b: Wang S, Wang P, Li X, Sun W, Kong C, Lu S. Enhanced recovery after surgery pathway: association with lower incidence of wound complications and severe

hypoalbuminemia in patients undergoing posterior lumbar fusion surgery. J Orthop Surg Res. 2022;17(1):178. doi:10.1186/s13018-022-03070-z

Weinstein JN, Lurie JD, Tosteson TD, et al. Surgical vs nonoperative treatment for lumbar disk herniation: the Spine Patient Outcomes Research Trial (SPORT) observational cohort. JAMA. 2006;296(20):2451-2459. doi:10.1001/jama.296.20.2451

Wilson RJT, Davies S, Yates D, Redman J, Stone M. Impaired functional capacity is associated with all-cause mortality after major elective intra-abdominal surgery. Br J Anaesth. 2010;105(3):297-303. doi:10.1093/bja/aeq128

Wind J, Polle SW, Fung Kon Jin PHP, et al. Systematic review of enhanced recovery programmes in colonic surgery. Br J Surg. 2006;93(7):800-809. doi:10.1002/bjs.5384

Xu B, Xu WX, Lao YJ, Ding WG, Lu D, Sheng HF. Multimodal Nutritional Management in Primary Lumbar Spine Surgery: A Randomized Controlled Trial. Spine (Phila Pa 1976). 2019;44(14):967-974. doi:10.1097/BRS.0000000000002992

Youn MS, Shin JK, Goh TS, Lee JS. Clinical and radiological outcomes of endoscopic partial facetectomy for degenerative lumbar foraminal stenosis. Acta Neurochir (Wien). 2017;159(6):1129-1135. doi:10.1007/s00701-017-3186-0

Zander T, Rohlmann A, Klöckner C, Bergmann G. Influence of graded facetectomy and laminectomy on spinal biomechanics. Eur Spine J. 2003;12(4):427-434. doi:10.1007/s00586-003-0540-0

Zhang D, Sun K, Wang T, et al. Systematic Review and Meta-Analysis of the Efficacy and Safety of Enhanced Recovery After Surgery vs. Conventional Recovery After

Surgery on Perioperative Outcomes of Radical Cystectomy. Front Oncol. 2020;10:541390. doi:10.3389/fonc.2020.541390

Zhong M, Liu JT, Jiang H, et al. Incidence of Spontaneous Resorption of Lumbar Disc Herniation: A Meta-Analysis. Pain Physician. 2017;20(1):E45-E52.

Appendices

Appendix 1.1: Logic model detailing the function of each ERAS strategy, and how it may facilitate more efficient discharge.

Strategy	How it is supposed to work	Discharge criteria (outcomes)
Pre-operative		
Prehabilitation	Poor preoperative physical status has been shown to contribute to postoperative complications and prolonged disability (Wilson et al., 2010). Prehab programs attempt to improve the physical conditioning of the patient prior to surgery (Gustafsson et al., 2019). However, evidence is limited (Debono et al., 2021).	Could contribute to post-op mobilization and functional recovery.
Patient Education	Helps manage patient expectations regarding their recovery (Kong et al., 2010). For example, manage expectations regarding normal pain expectations, as well as expectations regarding exercise. Can help engage the patient with their own care, so they follow-through on exercise programs (Graffigna and Barello., 2018).	Patient understands what is expected of them in order to leave the hospital.
Pre-operative carbohydrate loading	Helps facilitate post-operative recovery by providing carbohydrates necessary to regain strength and can help patients engage in earlier mobilization (Xu et al., 2019).	Post-operative mobility
Fasting rules	Reduction in fasting. Patients able to eat closer to surgery, and drink as well. Helps facilitate post-op recovery (Nygren et al., 2015).	Post-operative mobility/nutrition
Comorbidity management	Helps prevent complications or helps manage expectations of patients with comorbidities regarding their recovery (Grasu et al., 2018).	Post-op mobility/prevents possible complications

Routine prophylaxis	Reduces the risk of post-op infection (Debono et al., 2021).	Reduces risk of complications after surgery which would increase LoS.
Pre-op multimodal pain approach/reduction of narcotics	Helps reduce post-op nausea, and improves recovery time in the PACU (Ogura et al., 2020). This can lead to earlier nutrition post-op as well as help aid in earlier ambulation (Davy et al., 2003).	Early nutrition and early ambulation, with ambulation being required for discharge.
Urinary retention monitoring	Helps determine what baseline urinary retention is. Evaluating if patient's have residual urine after they urinate will help facilitate discharge of the patient by showing if a residual is normal for that patient or not (Ali et al., 2017; Leitner et al., 2021).	Helps establish if residual urine in the bladder is normal or not for the patient. If this is unknown, the patient can't be discharged until they fully void or are cleared by urology.
Integration of family/caregiver with care	Help facilitates patient education, having a person that can also provide info on post-operative care for the patient. Also helps ensure logistically that someone is available logistically to pick up the patient from hospital. Also has a person that can help with adherence to post-op exercises or ambulation (Lee et al., 2018).	Help facilitate pick up of the patient as well as adherence to exercises.
Peri-operative		
Multimodal pain approach/reduction in narcotics	Helps reduce post-op nausea, and improves recovery time in the PACU. This can lead to earlier nutrition post-op as well as help aid in earlier ambulation (Mathiesen et al., 2013).	Early nutrition and early ambulation, with ambulation being required for discharge.
Minimally invasive approaches	Helps reduce incision size (reduces risk of complications), as well as minimizes post-operative pain due to the smaller incision (Grasu et al., 2018). Minimally invasive approaches cut through less muscle tissue, ligaments and other structures which reduces pain experienced by the patient (Fan et al., 2010).	Patients with reduced pain are easier to mobilize, need less post-op medication.

Reduction in Muscle relaxants	Muscle relaxants make post-op mobilization more difficult, so a reduction or cessation of muscle relaxants helps facilitate earlier mobilization of the patient (Staartjes et al., 2019).	Early mobilization
Restrictive use of surgical drains	Helps facilitate recovery of the patient by having less tubes inserted into the patient. (Ali et al., 2017).	Prevents increased risk of infection by reducing our eliminating the use of drains.
Prevention of hypothermia with warm air blankets	Helps prevent complications in the OR, such as increased blood loss or cardiac complications (Debono et al., 2021).	Helps patients overall, not so much a specific discharge criteria, as it prevents complications associated with hypothermia.
IV Lidocaine infusions	Part of the multimodal pain approach. Helps reduce the need for intra-op narcotics (Farag et al., 2013).	Early nutrition and early ambulation, with ambulation being required for discharge.
Post-operative		
Reduction or stoppage of indwelling foley catheters	Use of catheters can increase the risk or urinary tract infections while in. Stoppage or early stoppage of these catheters helps prevent these infections hospital (Ali et al., 2017). Foley catheters also prevent mobilization of the patient (Ali et al., 2017).	Helps prevent complications while in hospital which could delay discharge.
Standard PCA pump	Multimodal approach to pain management. Allows patients to get sedation when needed by them. Can help prevent the need for a physician to order narcotics for the patient (Kurtović et al., 2017; Lindley et al., 2015).	May aid in mobilization and early nutrition in that patients may not need narcotics if this is used. If narcotics are prevented from being needed, this can help reduce post-op nausea and confusion.
Multimodal analgesia approach/reduction in narcotics	Helps reduce nausea/vomiting as well as confusion or dizziness, and reduces LoS (Walker et al., 2020).	Reduction in post-op nausea and vomiting can help facilitate earlier mobility and nutrition.
Early mobilization	Mobilization is a key discharge requirement for patients, particularly those with	Helps patients mobilize earlier which can lead to earlier discharge. Mobility

	musculoskeletal disease. Mobilizing patients earlier will help them reach their mobility goals faster (Debono et al., 2021).	also helps facilitate being able to use the washroom independently.
Early nutrition	Allows patients to resume normal diet as quickly as tolerated. Patients who can resume diet earlier are able to regain their strength to mobilize quicker as well. Also helps facilitate evacuating bowels or voiding (Debono et al., 2021).	Helps mobility as well as regular function of the patient for using the washroom.

Appendix 1.2: A comparison of existing systematic reviews until 2020.

Author/year	Search dates	Study Designs	Population Location	Population Disease	Risk of Bias	GRADE	Meta-analysis	LoS Effect size	Readmissions
Elserrag et al., 2019	Inception-2018	UBA (n=19) Protocol (n=1)	Lumbar spine, cervical spine	Degenerative diseases, Deformity, tumor	No	No	No	13 studies significant reduction in LoS 2 studies non-significant reduction in LoS 5 studies reported no comparison	9 studies non-significant increase in re-admission 10 studies did not report a comparison for re-admission
Dietz et al., 2019	1990-2019	UBA (n=19) RCTs (n=0)	Lumbar spine, cervical spine	Degenerative diseases, Infection, deformity, trauma, neoplasm	QUADAS	No	No	9 studies significant reduction in LoS 3 studies non-significant reduction in LoS 9 reported no comparison for LoS	3 studies showed no significant difference in re-admission 16 studies did not compare re-admission

Tong et al., 2020	Inception- 2019	UBA (n=22) RCTs (n=0)	Lumbar spine, cervical spine	Degenerative diseases	Newcastle-Ottawa scale	No	No	7 studies significant reduction in LoS 3 studies non-significant reduction in LoS	5 studies showed no significant difference in re-admission 17 studies did not compare re-admission
Pennington et al., 2020	Inception-2020	UBA (n=13) RCTs (n=1)	Lumbar spine, cervical spine	Degenerative diseases, deformity	No	No	Yes	-1.22 (-1.98, -0.47) days	0.87 (0.67, 1.14) OR favoring ERAS

Appendix 2.1: Protocol for the stakeholder engagement study.

Development of an Enhanced Recovery After Surgery Protocol for Elective Spine Surgery for Degenerative Pathologies of the Spine

Ryan Greene, Amanda Hall, Holly Etchegary, Thomas Wainwright, and Sean Christie

Introduction:

Length of stay (LoS) is problematic for patients and healthcare systems alike. For patients, each day they remain in hospital increases their risk of adverse events such as urinary tract infections or pneumonia by 5% (Matthew et al., 2018), and patients who are discharged earlier are more satisfied with their procedure (Blackburn et al., 2016). For healthcare systems, LoS is costly, and in some cases the post-op hospital stay outweighs the cost of the procedure itself (Matthew et al., 2018). Patients undergoing spine surgery in particular, face particular difficulties regarding pain management and disability during their recovery. In other surgical fields, such as colorectal or bariatric surgery, enhanced recovery after surgery (ERAS) protocols have been implemented to reduce patient LoS without increasing the risk of re-admission to hospital (Soffin et al., 2019).

In the fall of 2019, in consultation with Dr. Thomas Wainwright, an international expert in ERAS, the Division of Neurosurgery at Dalhousie University at the Queen Elizabeth II (QEII) Hospital, in Halifax, Nova Scotia, planned a quality improvement project to align spinal surgery procedures with ERAS protocols in other surgical areas. To develop the ERAS protocol for spinal surgery at our site, four steps were suggested, including a local stakeholder engagement initiative and two academic studies:

(i) Stakeholder engagement: the aim of this was to gain an understanding of what type of strategies should be included in an ERAS intervention protocol from the stakeholders' perspective. This included two parts:
   a. a brief literature review to identify strategies previously used in ERAS interventions to generate a comprehensive list of potential ERAS strategies for spinal surgery
   b. A discussion group: to obtain stakeholder input on strategies to inform a final ERAS intervention protocol

(ii) A quality assurance study: Conduct a formal assessment of reasons for non-discharge to identify focused areas for improvement

(iii) A systematic review: to update the formal evidence base on the effectiveness of ERAS strategies for spinal surgeries

The purpose of this report is to describe how we completed step 1 to inform the development of an ERAS protocol specific to spinal surgery at our site and within our hospital's resources. Steps 2 and 3 are being implemented as separate studies, both of which are underway (Greene et al., 2021).

Methods:

Design: A brief literature review and a stakeholder engagement discussion group were used to obtain a comprehensive list of ERAS strategies and an assessment of their acceptability, practicality and affordability. Both methods are described below. As this was a quality improvement initiative, ethics was not required (Doria et al., 2018).

Brief literature review:

This process involved searching one database (Pubmed) using related search terms for ERAS, spine and surgery. Additionally, the ERAS website (link) was reviewed for any existing guidelines or papers about ERAS interventions. Any study that described an ERAS intervention for any of the three surgical phases (pre-, peri- or post-operative) was included. A standardised data extraction sheet was used to compile data related to study characteristics, intervention strategies, and outcomes assessed. All intervention strategies that were described in any of the included studies were summarised within their respective surgical phase: pre-, peri- or post-operative.

Stakeholder Discussion Group:

This involved identifying and inviting relevant members of the hospital staff (Identifying key team members was performed by SDC and RG) to attend one of three discussion groups about potential ERAS strategies. Included hospital staff included spine surgeons (neurosurgery and orthopaedic surgery), anesthesiologists, a nurse practitioner, clinic nurses, and inpatient floor nurses, as well as researchers. In brief, the discussion group used a guide with open-ended questions and was facilitated by three research team

members with relevant experience in the content area and in qualitative research, field notes were taken, and a summary of the discussion and decisions made were documented and presented as a list of recommendations for how to implement ERAS at our facility. Discussion groups are similar to qualitative focus groups; however, as a method of patient and public engagement, their purpose is to inform the development and design of a research protocol rather than answer a specific research question (Doria et al., 2018). Since there are no formal reporting guidelines for discussion group studies, we have structured our reporting following the headings for reporting for qualitative studies outlined in the SRQR reporting guidelines (O'Brien et al., 2014).

Researcher Characteristics: All group members and their roles can be seen in Table 1. This effort was led by Dr. Sean Christie and Ryan Greene, with the assistance of ERAS expert, Dr. Tom Wainwright. This group of individuals included a broad variety of clinical professions and researchers, and each invited participant was invited due to their particular expertise (Doria et al., 2018). Dr. Christie is a spine neurosurgeon, and Director of research in the Division of Neurosurgery at Dalhousie University who helped facilitate engagement of the project by his fellow surgeons, floor and clinic nurses, as well as other allied health. Ryan Greene is a master's level researcher in the spine research program at the Halifax Infirmary, under the supervision of Dr. Christie, who performed the literature review, protocol development, procured funding, and facilitated meetings and note transcription for the stakeholder engagement group. Dr. Thomas Wainwright is a Professor of Orthopaedics at Bournemouth University. Dr. Wainwright is an expert in enhanced recovery protocols, having helped develop ERAS programs

internationally, and has developed consensus statements for ERAS guidelines for the ERAS Society. Dr. Wainwright is trained as a physiotherapist and obtained his PhD in Healthcare Management, with a focus on quality improvement. Dr. Wainwright was flown into Halifax, Nova Scotia to provide his expertise as a result of funding secured via a Translating Research Into Care grant.

Context: The study is set within one hospital, the Queen Elizabeth II Hospital in Halifax, Nova Scotia, Canada.

Sampling Strategy: Representatives from each component of the of patient care pathway (including surgeons, anesthesiologists, nurses, residents and researchers) were invited to participate. These professionals were contacted either in person, or via email individually. For contact purposes, Dr. Christie spoke with other surgeons personally and some nursing staff, while Ryan Greene emailed anesthesiologists identified by Dr. Christie, and spoke or emailed the remaining surgeons, nurses and researchers also identified by Dr. Christie. After initial contact by either Dr. Christie or Ryan, the group was emailed as a whole to facilitate future correspondence by Ryan. Interested stakeholders were provided a discussion group time depending on which discussion group best pertained to their professional role: pre-survey discussion group, peri-discussion group, or a post-operative discussion group.

Data Collection Methods:

(i) *Pre-discussion groups data collection*: Two weeks prior to the discussion group time, each participant was sent a 2-page summary of the brief literature review that outlined what ERAS was, what was known about its general effectiveness from recent systematic reviews and a comprehensive list of the strategies included in ERAS protocols for their respective surgical phase (pre, peri or post). Each participant was asked to review the document and comment on what strategies they thought could be implemented in our facility, which ones they thought would be most relevant and why and to add any additional strategies they thought might be missing from the list. This correspondence was performed mainly via email but in 2 cases was performed during one-on-one conversations in-person/phone.

(ii) *Discussion group data collection:* Three 1-hr discussion groups were held in October 2019. Each focused on one of the surgical phases: pre-, peri-, or post-operative care. During these discussion groups, each of the potential strategies identified for that surgical phase was discussed. This involved discussing how the strategy contributed to improving patient outcomes, if it was feasible to implement locally, and what barriers could prevent implementation. Ideally, we aimed to reach consensus about whether or not the potential strategy should be used as part of an ERAS intervention at our site. After each meeting, key points discussed during the meeting would be reiterated to ensure that each team member was in agreement of what was discussed. In issues where a consensus could not be met, expert opinion and majority vote would decide whether a topic was included or not. After each strategy was discussed for possible inclusion or exclusion, we also

discussed potential barriers or enablers that might prevent or help the actual implementation of the strategy. All opinions were captured for data collection purposes. The discussion groups were not audio recorded. Detailed field notes were taken for each strategy. At the end of each session, summarized points of the discussion were explained to the group, to ensure consensus and make sure no other outstanding issues were missed. Field notes were taken by attendees on either print outs of the proposed ERAS pathway, or by the facilitator on a clipboard. Remaining questions surrounding care, and barriers to discharge were also observed, having hypothesis generation a key component of the meeting as well.

Development of Key Recommendations:

Each component of each ERAS pathway was discussed during the stakeholder engagement sessions. Each group had their own specific phase of ERAS (pre-, peri-, and post-operative) to focus on. As per Doria et al. (2018), this type of discussion group format does not require a formal data analysis, unlike a focus group which would use more formal quality improvement analyses, such as transcript coding or thematic analysis. As such, the information from these discussion groups will, focus on main themes that reflect the conversations held during the discussion groups.

Techniques to Enhance Trustworthiness:

All data was saved via email backups or were transcribed during meetings and then digitized.

Funding:

A Translating Research Into Care (TRIC) Grant was obtained in 2019, valued at $3000 was obtained for this project from the QEII Foundation Healthcare Improvement Research Program. This funding was used to cover travel expenses for Dr. Wainwright.

References:

Blackburn, J., Madhaven, P., Leung, Y. L., and Walburn, M. An Enhanced Recovery Program for Elective Spinal Surgery Patients. Journal of Clinical Outcomes Management. 2016. 23 (10).

Corniola MV, Meling TR, Tessitore E. Enhanced recovery after spine surgery-a multinational survey assessing surgeons' perspectives. Acta Neurochir (Wien). 2020;162(6):1371-1377. doi:10.1007/s00701-020-04293-x

Doria N, Condran B, Boulos L, Curtis Maillet DG, Dowling L, Levy A. Sharpening the focus: differentiating between focus groups for patient engagement vs. qualitative research. Res Involv Engagem. 2018;4:19. doi:10.1186/s40900-018-0102-6

Ljungqvist O. ERAS—Enhanced Recovery After Surgery. Journal of Parenteral and Enteral Nutrition. 2014;38(5):559-566. doi:10.1177/0148607114523451

Maessen J, Dejong CHC, Hausel J, et al. A protocol is not enough to implement an enhanced recovery programme for colorectal resection. British Journal of Surgery. 2007;94(2):224-231. doi:10.1002/bjs.5468

Mathew PJ, Jehan F, Kulvatunyou N, et al. The burden of excess length of stay in trauma patients. Am J Surg. 2018;216(5):881-885. doi:10.1016/j.amjsurg.2018.07.044

Ogrinc G, Davies L, Goodman D, Batalden P, Davidoff F, Stevens D. SQUIRE 2.0 (Standards for QUality Improvement Reporting Excellence): revised publication guidelines from a detailed consensus process. BMJ Qual Saf. 2016;25(12):986-992. doi:10.1136/bmjqs-2015-004411

Pearsall EA, McLeod RS. Enhanced Recovery After Surgery: Implementation Strategies, Barriers and Facilitators. Surgical Clinics of North America. 2018;98(6):1201-1210. doi:10.1016/j.suc.2018.07.007

Soffin et al. An enhanced recovery after surgery pathway: association with rapid discharge and minimal complications after anterior cervical spine surgery. Spine. 2019. 44(9): E561-E570. DOI: 10.1097/BRS.0000000000002905

Wainwright, T. W., Immins, T., and Middleton, R. G. 2016. Enhanced recovery after surgery (ERAS) and its applicability for major spine surgery. Best Practice & Research Clinical Anaesthesiology. 30(1) 91-102

The EQUATOR Network | Enhancing the QUAlity and Transparency Of Health Research. Accessed July 18, 2022. https://www.equator-network.org/

Appendix 3.1: Search strings for each database.
PubMed:

("Enhanced Recovery After Surgery"[Mesh] OR ERAS[tiab] OR "enhanced recovery"[tiab] OR (("Critical Pathways"[Mesh] OR "critical path"[tiab] OR "clinical pathway*"[tiab] OR "clinical path"[tiab] OR "clinical paths"[tiab] OR "multimodal pathway*"[tiab] OR pathway*[ti]) AND ("Postoperative Care"[Mesh] OR "Perioperative Care"[Mesh:NoExp] OR recovery[tiab] OR postoperative[tiab] OR "post operative"[tiab] OR perioperative[tiab] OR "perioperative"[tiab] OR surgical[tiab] OR surger*[tiab]))

AND

("Spine/surgery"[Mesh] OR "Back/surgery"[Mesh] OR "Spinal Diseases/surgery"[Mesh] OR "Spinal Fusion"[Mesh] OR "Vertebroplasty"[Mesh] OR "Diskectomy"[Mesh] OR "Laminectomy"[Mesh] OR "Laminoplasty"[Mesh] OR "Foraminotomy"[Mesh] OR ((spine[tiab] OR spinal[tiab] OR lumbar[tiab] OR stenosis[tiab] OR spondylolisthesis[tiab]) AND (surger*[tiab] OR surgical[tiab] OR fusion[tiab])) OR "spinal decompression"[tiab] OR discectomy[tiab] OR diskectomy[tiab] OR laminectomy[tiab] OR laminoplasty[tiab] OR laminotomy[tiab] OR foraminotomy[tiab] OR facetectomy[tiab] OR spondylolisthesis[tiab] OR TLIF[tiab] OR PLIF[tiab] OR ALIF[tiab] OR LLIF[tiab] OR XLIF[tiab] OR OLIF[tiab] OR "anterior column realignment"[tiab]))

NOT (Animals[Mesh] NOT Humans[Mesh])

Embase (via embase.com):

('enhanced recovery after surgery'/de OR 'enhanced recovery':ab,ti OR eras:ab,ti OR 'clinical pathway'/de OR 'critical pathway*':ab,ti OR 'critical path':ab,ti OR 'critical paths':ab,ti OR 'clinical pathway*':ab,ti OR 'clinical path':ab,ti OR 'clinical paths':ab,ti OR 'multimodal pathway*':ab,ti OR pathway*:ti) AND ('postoperative period'/de OR 'perioperative period'/de OR recovery:ab,ti OR postoperative:ab,ti OR 'post operative':ab,ti OR perioperative:ab,ti OR 'peri operative':ab,ti OR surgical:ab,ti OR surger*:ab,ti) AND ('spine surgery'/exp OR ((spine:ab,ti OR spinal:ab,ti OR lumbar:ab,ti OR stenosis:ab,ti OR spondylolisthesis:ab,ti)

AND (surger*:ab,ti OR surgical:ab,ti OR fusion:ab,ti)) OR 'spinal decompression':ab,ti OR discectomy:ab,ti OR iscectomy:ab,ti OR laminectomy:ab,ti OR laminoplasty:ab,ti OR laminotomy:ab,ti OR foraminotomy:ab,ti OR facetectomy:ab,ti OR spondylolisthesis:ab,ti OR tlif:ab,ti OR plif:ab,ti OR alif:ab,ti OR llif:ab,ti OR xlif:ab,ti OR olif:ab,ti OR 'anterior column realignment':ab,ti)

NOT ('animal'/exp NOT 'human'/exp)

CINAHL (via EBSCOhost):

(MH "Enhanced Recovery After Surgery" OR TI "enhanced recovery" OR AB "enhanced recovery" OR TI ERAS OR AB ERAS OR ((MH "Critical Path" OR TI pathway* OR TI "critical path" OR TI "critical paths" OR TI "clinical path" OR TI "clinical paths" OR AB "critical pathway*" OR AB "critical path" OR AB "critical paths" OR AB "clinical

pathway*" OR AB "clinical path" OR AB "clinical paths" OR AB "multimodal pathway*") AND (MH "Postoperative Care" OR MH "Postoperative Period" OR MH "Perioperative Care" OR TI recovery OR TI postoperative OR TI "post operative" OR TI perioperative OR TI "peri operative" OR TI surgical OR TI surger* OR AB recovery OR AB postoperative OR AB "post operative" OR AB perioperative OR AB "peri operative" OR AB surgical OR AB surger*)))

AND

(MH "Spine+/SU" OR MH "Back/SU" OR MH "Spinal Diseases+/SU" OR MH "Spinal Fusion" OR MH "Vertebroplasty+" OR MH "Diskectomy" OR MH "Laminectomy" OR MH "Laminoplasty" OR ((TI spine OR TI spinal OR TI lumbar OR TI stenosis OR TI spondylolisthesis) AND (TI surger* OR TI surgical OR TI fusion)) OR TI "spinal decompression" OR TI discectomy OR TI discectomy OR TI laminectomy OR TI laminoplasty OR TI laminotomy OR TI foraminotomy OR TI facetectomy OR TI spondylolisthesis OR TI TLIF OR TI PLIF OR TI ALIF OR TI LLIF OR TI XLIF OR TI OLIF OR TI "anterior column realignment" OR ((AB spine OR AB spinal OR AB lumbar OR AB stenosis OR AB spondylolisthesis) AND (AB surger* OR AB surgical OR AB fusion)) OR AB "spinal decompression" OR AB discectomy OR AB discectomy OR AB laminectomy OR AB laminoplasty OR AB laminotomy OR AB foraminotomy OR AB facetectomy OR AB spondylolisthesis OR AB TLIF OR AB PLIF OR AB ALIF OR AB LLIF OR AB XLIF OR AB OLIF OR AB "anterior column realignment")

Appendix 3.2: Comparison of other Spine ERAS systematic reviews.

Author/ year	Search dates	Study Designs	Population Location	Population Disease	Risk of Bias	GRADE	Meta-analysis	LoS Effect size	Readmissions
Elserrag et al., 2019	Inception-2018	UBA (n=19) Protocol (n=1)	Lumbar spine, cervical spine	Degenerative diseases, Deformity, tumor	No	No	No	13 studies significant reduction in LoS 2 studies non-significant reduction in LoS 5 studies reported no comparison	9 studies non-significant increase in re-admission 10 studies did not report a comparison for re-admission
Dietz et al., 2019	1990-2019	UBA (n=19) RCTs (n=0)	Lumbar spine, cervical spine	Degenerative diseases, Infection, deformity, trauma, neoplasm	QUADAS	No	No	9 studies significant reduction in LoS 3 studies non-significant reduction in LoS 9 reported no comparison for LoS	3 studies showed no significant difference in re-admission 16 studies did not compare re-admission

Tong et al., 2020	Inception-2019	UBA (n=22) RCTs (n=0)	Lumbar spine, cervical spine	Degenerative diseases	Newcastle-Ottawa scale	No	No	7 studies significant reduction in LoS 3 studies non-significant reduction in LoS	5 studies showed no significant difference in re-admission 17 studies did not compare re-admission
Pennington et al., 2020	Inception-2020	UBA (n=13) RCTs (n=1)	Lumbar spine, cervical spine	Degenerative diseases, deformity	No	No	Yes	-1.22 (-1.98, -0.47) days	0.87 (0.67, 1.14) OR favoring ERAS

Appendix 3.3: Protocol for the systematic review, as found online at Open Science Framework.

The Effect of Enhanced Recovery After Surgery Protocols for Elective Cervical and Lumbar Spine Procedures on Hospital Length of Stay: A Systematic Review and Meta-Analysis

Introduction:

Length of hospital stay after surgery is a problem for many procedures, such as colorectal, bariatric, cardiac and total hip and knee replacement surgery. For example, in colorectal surgery, a normal length of stay (LoS) for a colonic resection was 9-10 days[1]. Each day in hospital is associated with 5% higher odds of complications[2] (e.g. urinary tract infection, pneumonia) and increased risk for infection[3]. Prolonged LoS can pose a significant cost to

the health care system[2] and it reduces available beds for patients in both spinal surgery as well as other services (e.g. critical care). Patients who experience a shorter LoS are also more satisfied with their surgical experience[4, 5]. In an effort to reduce LoS after surgery and thereby reduce complications associated with increased LoS, Henrik Kehlet developed a fast-track to recovery program for colorectal surgery in 1999, which took the average LoS for a colonic resection from 9-10 days, to just 2 days[6]. The primary aim of the program changed in the early 2000's to improving patient outcomes with LoS being a secondary outcome, resulting in a program name change from "fast-track approach" to "enhanced recovery after surgery (ERAS)"[1].

Enhanced recovery after surgery is an optimized pathway designed to improve a patient's recovery after surgery. The approach to ERAS is both multi-disciplinary and multi-modal, requiring a diverse team of healthcare professionals to facilitate an optimized surgical pathway as determined by the culmination of best practices and evidence-based medicine. The total pathway is designed to reduce patient length of stay (LoS), cost to the healthcare system, and re-admission rates to hospital while simultaneously improving patient reported outcome measures[7]. Each ERAS pathway focuses on different phases of the patient's surgical journey, specifically the pre-, peri-, and post-operative components of their care (Table 1). For each phase of the pathway, different components are improved on to deliver enhanced recovery, such as patient education material, reduction of narcotics in the operating room, and post-operative early mobilization of patients (Table 1).

While ERAS is established in many fields, there is still no definitive guideline available for major spine surgery (e.g. such as decompression, and decompression and fusion

procedures). Spine surgery in particular would benefit greatly from the implementation of an ERAS program to improve patients post-operative outcomes such as post-operative pain, and complications (e.g. urinary tract infection, pneumonia), which lead to high and long and variable LoS's and high-costs for the health system[8]. Early research into implementation of ERAS for major spine surgery is promising, and illustrates the need for such a program. In the literature, LoS for major spine surgery is variable from study to study, with a pre- ERAS LoS ranging from hours[9] to several days[7, 10, 11, 12], with the average in the United States being 4 days in 2010[13]. All studies which implemented ERAS saw an improvement in LoS[7, 9-12]. With the decreased LoS, cost savings were also commonly reported, and significantly decreased when compared to baseline costs[12]. However, the success of implementing an ERAS program for spine varies widely due to how recently ERAS has been introduced to elective spine procedures. Furthermore, LoS varies significantly from study to study. To date there has been no systematic review that has evaluated the effectiveness of ERAS for spine surgeries. A previous review included some of the studies we would be interested in but it was not a complete list. Thus, the aim of this systematic review is to identify the overall effect of implementing a spine ERAS program on patient LoS and associated readmissions.

Objective

Primary objective: To determine the effect of implementing the ERAS intervention on length of stay for patients undergoing elective spine surgery.

Secondary Objectives: Re-admission to hospital within 30 days of discharge, and cost per patient per surgery will be secondary outcomes.

Methods

Design: A systematic review and meta-analysis will be performed in accordance with the PRISMA guidelines.

Search Strategy:

Databases: We will search the following databases PubMed, CINAHL and Embase.

Search terms: We used previous search strategies to inform the selection of search terms for each of the following components: spinal surgeries, enhanced recovery after surgery, and pre-, peri-, intra and post-operative care. The search strategy was developed in consultation with a health research librarian (MS). A copy of the search strategy can be found in Appendix 1.

Process: The search will be conducted by RG and downloaded to Covidence Software.

Supplemental search methods: Both forward and backward citation tracking will also be done in order to identify potential studies not captured in the initial search strategy.

Study Selection

Inclusion criteria:

Design: Study design will be one of the following: Our primary aim is to include randomized trials as the gold standard design for intervention effectiveness followed by non-randomized controlled trials (or controlled before and after studies). However, we know from a previous literature search and systematic reviews in this area that there are few RCTs or non-RCTs. Thus, to provide a comprehensive summary of the evidence, we

have included the more common designs used to test ERAS interventions for spinal surgeries – interrupted timeseries and uncontrolled before and after studies.

Population: Studies will be included if they include patients aged 18 years and older who have a chronic cervical or lumbar spine pain condition (e.g. Spinal Stenosis, spondylolisthesis, disc herniation, myelopathy) and are undergoing an elective lumbar or cervical decompression or fusion spinal surgery (e.g. Decompression: Laminectomy, Facetectomy, Discectomy; Fusion: Anterior Lumbar, Transforaminal lumbar, Posterior lumbar, Lateral Lumbar Interbody Fusions or Anterior Cervical Discectomy and fusion).

Intervention: Studies will have to include a fully developed ERAS pathway, and can't have only partial implementation of the protocol. The comparator will be standard of care.

Comparison: Usual standard of care will be the comparator.

Outcome: All studies must state length of stay as a primary or secondary outcome for patients who have undergone either a decompression procedure, or a decompression and fusion with a surgical indication that allows for an elective procedure.

Additional exclusion criteria:

Studies will be excluded if the procedure is for an acute injury, tumor, deformity or any day-surgery (e.g. minimally invasive surgery for a single level). Patients undergoing surgery with a minimally invasive approach (e.g. micro-discectomy) will also be excluded.

Appendix 2 presents the study selection screening form with a complete list of the inclusion and exclusion criteria for each of the PICO elements

Process: The Covidence software program automatically removes duplicates from the imported database searches. Thus, the remaining studies will be independently screened by two reviewers (RG and JSF). The reviewers will start with a title/abstract search, removing all papers which were not related to spine procedures or related to ERAS. After this, each reviewer will complete a full text review of the remaining papers to see if the papers meet the inclusion/exclusion criteria using an eligibly screening form in excel. In all cases, where discrepancies in decision making are found, a third reviewer (SC or AH) will decide if the study should be included or not.

Data extraction

Data elements: Length of stay data will be recorded in days stayed in hospital after surgery. If hours are recorded, that data will be converted to days. Length of stay will be described with means and standard deviations. Similarly, re-admission rates to hospital (within 30 days of discharge) will also be recorded as means and standard deviations. Length of stay and re-admission to hospital data will be described based on whether the group was provided the ERAS intervention or provided the conventional treatment group. Patient age, BMI and sex will also be described, with age and BMI being shown with means and standard deviations, and sex as frequencies and percentages.

Process: The TiDieR guidelines will be used to describe the intervention. One author (RG) will extract all data from the studies included for the systematic review, with a second author (BF) checking the data for any potential errors. The same first author will then pool all of the data elements once extracted. All papers included will have LoS data

averaged (with standard deviation) and secondary outcomes pooled as well if collected as an outcome in the included paper.

Analysis:

Individual Study Risk of Bias: The Risk Of Bias In Non-Randomized Studies-of Interventions (ROBINS-I) criteria will be used to assess bias for this study. This method will be used as it is unlikely that randomized control trials will be included in the analyses, as it is difficult to implement an RCT for surgical interventions.

Bias will be assessed based on the domains found in the ROBINS-I criteria:

Pre-Intervention: Bias due to confounding, or bias due to selection of study participants.

During intervention: Bias in classification of intervention.

Post-Intervention: Bias due to deviations of the intended intervention, bias due to missing data, bias in measurement of outcomes, and bias in the selection of the reported results.

After pooling the severity of bias of each criterion, each paper will be judged as either being at low risk, moderate risk, serious risk or critical risk of bias, or if there is no information available.

Meta-analysis: A meta-analysis will be performed for randomised and non-randomised controlled trials. Due to the likelihood of all studies being non-randomized designs, we will downgrade the quality of evidence in this event. We will use a random effects model, with the assumption that all studies included feature the underlying effect of implementing an ERAS Spine program on a patient's hospital LoS. Furthermore, this

model is the ideal method to perform the meta-analysis as there will likely be a small cohort of studies included for this review. If there are sufficient studies, a funnel plot will be used to graphically show bias, pitting treatment effect against a measure of study size. To measure heterogeneity, the I^2 value will be calculated and we will assume that a value of 75% or higher will be represent high statistical heterogeneity that would warrant considering if the meta-analysis should be performed.

A forest plot will be generated for each meta-analysis, featuring all eligible studies including the and their effect size and confidence intervals. The forest plot will show whether implementing a spine ERAS protocol will decrease or increase hospital length of stay as compared to standard of care.

Grade:

For all meta-analyses, we will evaluate the confidence or certainty in the pooled estimate using the Grading of Recommendations, Assessment, Development and Evaluations (GRADE) approach .

The GRADE approach is used to assess over-all quality of the evidence. Quality will be downgraded based on five factors;

(i) **methodological quality**

(ii) **inconsistency in the results**

(iii) **indirectness of evidence**

(iv) **imprecision of evidence**

(v) **Publication Bias**

- **High-quality evidence**: there are consistent findings among at least 75% of studies with low risk of bias, consistent, direct, and precise data and no known or suspected publication biases. Further research is unlikely to change either the estimate or our confidence in the results;
- **Moderate-quality evidence**: one of the domains is not met. Further research is likely to have an important impact on our confidence in the estimate of effect and may change the estimate
- **Low-quality evidence**: two of the domains are not met. Further research is very likely to have an important impact on our confidence in the estimate of effect and is likely to change the estimate
- **Very low-quality evidence**: three of the domains are not met. We are very uncertain about the results;
- **No evidence**: no RCTs were identified that addressed this outcome.

Table 1: Description of a conventional ERAS pathway, featuring key components that can be improved at the pre-, peri-, and post-operative phase of the surgical pathway.

Phase	Normal Pathway	Examples of ERAS pathway
Pre-	**Education:** General patient education about the procedure itself, and post-op care of the patient. Generally delivered by the surgeon, or in a handbook or pamphlet or video. **Nutrition:** For nutrition, no oral intake for 8 hours prior to surgery.	**Education:** Entwined patient engagement and education. Patient classroom sessions, online videos, and patient education for family members or caregivers. Manage expectations for the patient regarding post-op mobilization, exercise plan, and logistics for discharge. **Nutrition:** For nutrition, clear fluids permitted 2 hours prior to surgery, carbohydrate loading 4 hours prior to surgery. Also work with nutritionist pre-op in order to help tailor a post-op recovery diet to accelerate oral intake if possible.
Peri-	**Anesthesia:** Generally anesthetist's preference. **Catheters:** Use as needed.	**Anesthesia:** Reduced use of narcotics when possible. Possibly use local anesthetic as a "top-up" at the end of surgery.

	Surgical Approach: Provider preference.	**Catheters:** Avoid if possible, reduce length of catheterization if needed. **Surgical Approach:** Minimally invasive techniques should be employed as often as possible.
Post-	**Pain management:** Provider preference, usually involves post-op prescription of narcotics. **Mobilization:** Not usually consistently monitored, done when the patient feels up to it or requests it. **Oral Intake:** Patients resume clear liquids on post-op day 1, and diet advances as tolerated after.	**Pain management**: Pre-printed orders tailored to the procedure. Narcotics won't be included on the PPO, but can be prescribed easily if needed. Some ERAS protocols use a pain pump so the patient can manage their own pain. Or use VAS scales to determine if specific medication is needed if PPO is not sufficient. **Mobilization:** Mobilization within hours of surgery. Aim to have set goals for sitting up, walking or stretching each day for the patient to meet. Have nursing staff, or PT/OT ready for early mobilization. **Oral Intake**: Patients begin clear liquids on day of surgery. May also consume ice chips on day 0 post-op. Then resume diet as tolerated.

References:

1. Ljungqvist, O. 2014. ERAS—Enhanced Recovery After Surgery. Journal of Parenteral and Enteral Nutrition. 38(5):559-566

2. Mathew, P. J., Jehan, F., Kulvatunyou, N., Khan, M., O'Keefe, T., Tang, A., Gries, L., Hamidi, M., Zakaria, E-R., and Joseph, B. 2018. The burden of excess length of stay in trauma patients. The American Journal of Surgery. 216(5): 881-885

3. Pulido, L., Ghanem, E., Joshi, A., Purtill, J. J., and Parvizi, J. 2008. Periprosthetic joint infection: the incidence, timing, and predisposing factors. Clinical Orthopaedics and Related Research. 466(7): 1710-1715. DOI: 10.1007/s11999-008-0209-4

4. Blackburn, J., Madhaven, P., Leung, Y. L., and Walburn, M. 2016. An Enhanced Recovery Program for Elective Spinal Surgery Patients. Journal of Clinical Outcomes Management. 23 (10).

5. Debono, B., Corniola, M. V., Pietton, R., Sabatier, P., Hamel, O., and Tessitore, E. 2019. Benefits of Enhanced Recovery After Surgery for fusion in degenerative spine surgery: impact on outcome, length of stay, and patient satisfaction. Journal of neurosurgery. 46(4). DOI: 10.3171/2019.1.FOCUS18669

6. Kehlet, H., and Mogensen, T. 1999. Hospital stay of 2 days after open sigmoidectomy with a multimodal rehabilitation programme. British Journal of surgery. 86(2): 227–230

7. Dagal., A., Bellabarba, C., Bransford, R., Zhang, F., Chesnut, R. M., O'Keefe, G. E., Wright, D. R., Dellit, T. H., Painter, I., and Souter, M. J. 2018. Enhanced Perioperative Care for Major Spine Surgery. Spine. DOI: 10.1097/BRS.0000000000002968

8. Wainwright, T. W., Immins, T., and Middleton, R. G. 2016. Enhanced recovery after surgery (ERAS) and its applicability for major spine surgery. Best Practice & Research Clinical Anaesthesiology. 30(1) 91-102

9. Soffin et al., 2019. An enhanced recovery after surgery pathway: association with rapid discharge and minimal complications after anterior cervical spine surgery. Spine. 44(9): E561-E570. DOI: 10.1097/BRS.0000000000002905

10. Wang, M. Y., Chang, P-Y. C., and Grossman, J. 2017. Development of an Enhanced Recovery After Surgery (ERAS) approach for lumbar spinal fusion. Journal of Neurosurgery. 26 (4): 411-418

11. Bradywood, A., Farrokhi, F., Williams, B., Kowalczyk, M., and Blackmore, C. C. 2017. Reduction of Inpatient Hospital Length of Stay in Lumbar Fusion Patients with Implementation of an Evidence-Based Clinical Care Pathway. Spine. 42(3): 169-176.

12. Blackburn, J., Madhaven, P., Leung, Y. L., and Walburn, M. 2016. An Enhanced Recovery Program for Elective Spinal Surgery Patients. Journal of Clinical Outcomes Management. 23 (10).

13. Goz, V., Weinreb, J. H., McCarthy I., Schwab, F., Lafage, V., and Errico, T. J. 2013. Perioperative complications and mortality after spinal fusions: analysis of trends and risk factors. Spine. 38: 1970–1976

Appendix 1: Search strings for each database.

PubMed:

("Enhanced Recovery After Surgery"[Mesh] OR ERAS[tiab] OR "enhanced recovery"[tiab] OR (("Critical Pathways"[Mesh] OR "critical path"[tiab] OR "clinical pathway*"[tiab] OR "clinical path"[tiab] OR "clinical paths"[tiab] OR "multimodal pathway*"[tiab] OR pathway*[ti]) AND ("Postoperative Care"[Mesh] OR "Perioperative Care"[Mesh:NoExp] OR recovery[tiab] OR postoperative[tiab] OR "post operative"[tiab] OR perioperative[tiab] OR "perioperative"[tiab] OR surgical[tiab] OR surger*[tiab]))

AND

("Spine/surgery"[Mesh] OR "Back/surgery"[Mesh] OR "Spinal Diseases/surgery"[Mesh] OR "Spinal Fusion"[Mesh] OR "Vertebroplasty"[Mesh] OR "Diskectomy"[Mesh] OR "Laminectomy"[Mesh] OR "Laminoplasty"[Mesh] OR "Foraminotomy"[Mesh] OR ((spine[tiab] OR spinal[tiab] OR lumbar[tiab] OR stenosis[tiab] OR

spondylolisthesis[tiab]) AND (surger*[tiab] OR surgical[tiab] OR fusion[tiab])) OR "spinal decompression"[tiab] OR discectomy[tiab] OR diskectomy[tiab] OR laminectomy[tiab] OR laminoplasty[tiab] OR laminotomy[tiab] OR foraminotomy[tiab] OR facetectomy[tiab] OR spondylolisthesis[tiab] OR TLIF[tiab] OR PLIF[tiab] OR ALIF[tiab] OR LLIF[tiab] OR XLIF[tiab] OR OLIF[tiab] OR "anterior column realignment"[tiab]))

NOT (Animals[Mesh] NOT Humans[Mesh])

Embase (via embase.com):

('enhanced recovery after surgery'/de OR 'enhanced recovery':ab,ti OR eras:ab,ti OR 'clinical pathway'/de OR 'critical pathway*':ab,ti OR 'critical path':ab,ti OR 'critical paths':ab,ti OR 'clinical pathway*':ab,ti OR 'clinical path':ab,ti OR 'clinical paths':ab,ti OR 'multimodal pathway*':ab,ti OR pathway*:ti) AND ('postoperative period'/de OR 'perioperative period'/de OR recovery:ab,ti OR postoperative:ab,ti OR 'post operative':ab,ti OR perioperative:ab,ti OR 'peri operative':ab,ti OR surgical:ab,ti OR surger*:ab,ti) AND ('spine surgery'/exp OR ((spine:ab,ti OR spinal:ab,ti OR lumbar:ab,ti OR stenosis:ab,ti OR spondylolisthesis:ab,ti)

AND (surger*:ab,ti OR surgical:ab,ti OR fusion:ab,ti)) OR 'spinal decompression':ab,ti OR discectomy:ab,ti OR iscectomy:ab,ti OR laminectomy:ab,ti OR laminoplasty:ab,ti OR laminotomy:ab,ti OR foraminotomy:ab,ti OR facetectomy:ab,ti OR spondylolisthesis:ab,ti OR tlif:ab,ti OR plif:ab,ti OR alif:ab,ti OR llif:ab,ti OR xlif:ab,ti OR olif:ab,ti OR 'anterior column realignment':ab,ti)

NOT ('animal'/exp NOT 'human'/exp)

CINAHL (via EBSCOhost):

(MH "Enhanced Recovery After Surgery" OR TI "enhanced recovery" OR AB "enhanced recovery" OR TI ERAS OR AB ERAS OR ((MH "Critical Path" OR TI pathway* OR TI "critical path" OR TI "critical paths" OR TI "clinical path" OR TI "clinical paths" OR AB "critical pathway*" OR AB "critical path" OR AB "critical paths" OR AB "clinical pathway*" OR AB "clinical path" OR AB "clinical paths" OR AB "multimodal pathway*") AND (MH "Postoperative Care" OR MH "Postoperative Period" OR MH "Perioperative Care" OR TI recovery OR TI postoperative OR TI "post operative" OR TI perioperative OR TI "peri operative" OR TI surgical OR TI surger* OR AB recovery OR AB postoperative OR AB "post operative" OR AB perioperative OR AB "peri operative" OR AB surgical OR AB surger*)))

AND

(MH "Spine+/SU" OR MH "Back/SU" OR MH "Spinal Diseases+/SU" OR MH "Spinal Fusion" OR MH "Vertebroplasty+" OR MH "Diskectomy" OR MH "Laminectomy" OR MH "Laminoplasty" OR ((TI spine OR TI spinal OR TI lumbar OR TI stenosis OR TI spondylolisthesis) AND (TI surger* OR TI surgical OR TI fusion)) OR TI "spinal decompression" OR TI discectomy OR TI discectomy OR TI laminectomy OR TI laminoplasty OR TI laminotomy OR TI foraminotomy OR TI facetectomy OR TI spondylolisthesis OR TI TLIF OR TI PLIF OR TI ALIF OR TI LLIF OR TI XLIF OR TI OLIF OR TI "anterior column realignment" OR ((AB spine OR AB spinal OR AB lumbar OR AB stenosis OR AB spondylolisthesis) AND (AB surger* OR AB surgical OR AB fusion)) OR AB "spinal decompression" OR AB discectomy OR AB discectomy OR AB laminectomy OR AB laminoplasty OR AB laminotomy OR AB foraminotomy OR AB facetectomy OR AB spondylolisthesis OR AB TLIF OR AB PLIF OR AB ALIF OR AB LLIF OR AB XLIF OR AB OLIF OR AB "anterior column realignment")

Appendix 2: PICO Table for the studies inclusion/exclusion criteria.

Term	Inclusion Criteria	Exclusion Criteria
P	All patients over 18 years of age undergoing elective spine surgery for posterior cervical and lumbar fusion procedures.	Spine surgery for trauma, deformity, tumour, or acute back pain. Day surgery, and surgery using minimally invasive techniques will be excluded.
I	Implementation of an enhanced recovery after surgery program for major spinal cord surgery. The program will involve the development of a pathway optimizing the patients care during the pre-, peri-, and post-operative phases of surgery.	Exclusion criteria includes studies which only partially implement ERAS.
C	Standard care for posterior cervical and lumbar fusion procedures will be the comparator.	
O	Length of stay will be the primary outcome. Re-admission rate to hospital, and cost per patient will be secondary outcomes.	Studies which don't include total hospital length of stay, or only provide cost saved after implementing ERAS. Also exclude any study which has a re-admission rate different than 30 days from discharge.
Design	Randomized control trials, cohort studies and retrospective studies will be included.	Qualitative studies will be excluded.
Language	English	Any study not in English.

Appendix 3.4: Secondary outcomes associated with spine ERAS studies. Table 3.4 A) Secondary outcomes observed in spine ERAS studies observed in the systematic review, B) Pain, C) Post-operative complications, D) satisfaction, E) functional ability, F) re-operation, G) opioid reduction, H) Cost , I) nutrition J) urinary retention.

A) Secondary outcomes observed in spine ERAS studies.

Outcome(s)	Kerolus 2021	Duojun 2021	Garg 2021	Heathcote 2019	Flanders 2020	d'Astorg 2020	Debono 2021	Debono 2019	Bradywood 2017	Li 2021	Li 2018	Smith 2019	Total
Pain	X	X	X		X	X			X	X	X	X	9
Post- operative complication			X	X			X	X		X	X		6
Satisfaction					X	X	X	X	X				5
Functional ability		X	X		X	X							4
re-operation			X				X	X					3
Opioid reduction	X				X							X	3
Cost		X		X									2
Nutrition										X			1
Urinary retention	X												1

B) Pain scores:

Pain (n=9)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Kerolus 2021	Pain scores	Scored from 0-10	On post-op day 0-10.
Duojun 2021	Visual analogue scale	Scored from 0-10.	Pre-op and the first three days of recovery.
Garg 2021	Visual analogue scale	Scored from 0-100, represented overall function as a result of pain.	Baseline, 1-month, 6-months, 12-months.
Flanders 2020	Health scale	Scored from 0-100, represented overall function as a result of pain.	Pre-op, inpatient stay, post-op at 1-month, 3-months and 6-months.
d'Astorg 2020	Visual analogue scale	Scored from 0-10.	Pre-op and post-op, no specific time stated.
Bradywood 2017	Post-operative pain levels	Scored from 0-10. Patients recorded as frequency of patients scoring <5.	Scored in the morning on post-op day 1 and 2.
Li 2021	Visual analogue scale	Scale ranging from 0-10, scored for both back and leg pain.	Scored on days 1-4 following surgery.
Li 2018	Visual analogue scale	Scale ranging from 0-10. Average and maximum score reported. "outbreak" pain scores (>5) also reported.	Scored three days following surgery.
Smith 2019	Numerical pain rating scale	Ranged from 0-100. Patients asked to score a minimum and maximum pain.	Asked daily following surgery.

C) Post-Operative complications:

Post-Operative complication (n=6)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Garg 2021	Clavien-Dindo grade tool	Scored from grade 1-5, with increasing grading representing worse complications.	Following the inpatient stay.
Heathcote 2019	Percentage of patients with a complication.	Percent.	Any point during the inpatient stay.
Debono 2021	Number of patients who experienced a post-operative complication.	Frequency and percent	Any point during the inpatient stay.
Debono 2019	Number of patients who experienced a post-operative complication.	Frequency and percent	Any point during the inpatient stay.
Li 2021	Reported as frequencies of the event occurring (such as infection, thrombosis or cerebrospinal fluid leak).	Frequency of event.	Any point during the inpatient stay.
Li 2018	Proportion of patients with various post-op complications, such as palsy, infection or a hematoma	Proportion of patients with the post-op event.	Anytime during the inpatient recovery following surgery.

D) Satisfaction scores.

Satisfaction (n=5)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Flanders 2020	Questions surrounding if patient expectations were met, and if the patient would recommend the surgical centre, or the surgeon.	Yes/No Answers.	At the end of the inpatient stay
d'Astorg 2020	Series of questions on satisfaction. Questions included , "do you think the surgery was effective", "would you be willing to go through the same procedure again?", and "how to do you rate the results of your surgery?"	Yes and no answers, or likert scale of worse, poor, fair, good and excellent.	Post-op, no other information provided.
Debono 2021	Satisfaction questionnaire	Series of questions asking of a patient was satisfied or very satisfied, or if they agreed or strongly agreed.	At the end of the inpatient stay
Debono 2019	Patients responded on a likert scale as if they were satisfied, very satisfied, not satisfied and very not satisfied.	Likert scale	15 days following surgery.
Bradywood 2017	Yes/No responses as to various outcomes related to patient satisfaction.	Questions included if they recommended the hospital, if the nurse kept them informed, if the patient was included in decision making, and if their pain was controlled.	At the end of the inpatient stay

E) Functional ability, as measured by the Oswestry disability index.

Functional ability (n=4)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Duojun 2021	ODI	Score from 0-100	Baseline, 3-days and 1-month.
Garg 2021	ODI	Score from 0-100	Baseline, 1-month, 6-months, 12-months.
Flanders 2020	ODI	Score from 0-100	Pre-op, inpatient stay, post-op at 1-month, 3-months and 6-months.
d'Astorg 2020	ODI	Score from 0-100	Pre-op and post-op, no specific time stated.

F) Re-operation.

Re-operation (n=3)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Garg 2021	Number of people with a re-operation.	Frequency and percent.	60-days.
Debono 2021	Frequency of re-operation within 90-days.	Frequency and percent.	90 days following surgery.
Debono 2019	Frequency of re-operation within 90-days.	Frequency and percent.	90 days following surgery.

G) Opioid reduction

Opioid Reduction (n=3)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Kerolus 2021	Morphine milligram equivalent	Amount of MME's consumed	Days 0-4 post-op
Flanders 2020	Recorded as inpatient PCA use, pre-op use of narcotics and post-op use of narcotics.	Frequency and percent.	Pre-op, inpatient stay, post-op at 1-month, 3-months and 6-months.
Smith 2019	Proportion of patients taking opioids	Proportion of patients taking opioids. Both short- and long-lasting opioids considered.	First three days following surgery

H) Cost.

Cost (n=2)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Duojun 2021	Cost per procedure per patient.	Yen	Following the patient being discharged from hospital.
Heathcote 2019	Cost per procedure per patient.	USD$	Following the patient being discharged from hospital.

I) Nutrition.

Nutrition (n=1)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Li 2021	Proportion of patients who received early nutrition.	Frequency and percent.	Immediately following surgery.

J) Urinary retention.

Urinary retention (n=1)			
Study	Measurement Tool/Method	Metric	Timepoint(s)
Kerolus 2021	Number of patients who experienced post-operative urinary retention.	Frequency and percent.	Any point during the inpatient stay.

Appendix 4.1: Ethics submission for the barriers to discharge study and letter of approval.

Nova Scotia Health NON-INTERVENTIONAL STUDY - Ethics Application Form (EAF)

Project Info.

File No: 1026525
Project Title: What factors prevent patients being discharged from hospital after major spine surgery?
Principal Investigator: Mr. Ryan Greene (Medicine\Surgery\Neurosurgery)
Start Date: 2021/03/04
End Date:
Keywords: Spine surgery, Spine, , Assessing Barriers, Neurosurgery

Question	Answer
Clinical Trials No.	

Project Team Info.

Principal Investigator

Prefix: Mr.
Last Name: Greene
First Name: Ryan
Affiliation: Medicine\Surgery\Neurosurgery
Position: PhD Student
Email: ryan.greene@nshealth.ca
Phone1: 902-473-3877
Phone2: 902-754-3337
Fax: 902-425-2620
Primary Address: Queen Elizabeth II HSC Room 3068, AJL Building 5909 Veterans Memorial Lane Halifax, Nova Scotia, B3H 2E2
Institution: Memorial University of Newfoundland
Country: Canada

Comments: I am currently a PhD student at Memorial University of Newfoundland, and a research coordinator in the Division of Neurosurgery for Nova Scotia Health. Team members from Memorial University of Newfoundland include: Dr. Amanda Hall | Sub-Investigator | Memorial University of Newfoundland Dr. Holly Etchegary | Sub-Investigator | Memorial University of Newfoundland

Other Project Team Members

Prefix	Last Name	First Name	Affiliation	Role In Project	Email
Mrs.	Julien	Lisa	Medicine\Surgery\Neurosurgery	Research Coordinator	lisa.julien@nshealth.ca
Dr.	Christie	Sean	Medicine\Surgery\Neurosurgery	Supervising Investigator	sean.christie@dal.ca
Dr.	Oxner	William	Medicine\Surgery	Sub-Investigator	WOXNER@DAL.CA
Dr.	Alant	Jacob	Medicine\Surgery\Neurosurgery	Sub-Investigator	jacob.alant@nshealth.ca
Dr.	Barry	Sean	Medicine\Surgery\Neurosurgery	Sub-Investigator	barrysp@cdha.nshealth.ca
Dr.	Glennie	Raymond (Andrew)	Medicine\Surgery\Orthopedic Surgery	Sub-Investigator	andrew.glennie@nshealth.ca

Common Questions

1. Principal Investigator Attestation/Commitments

#	Question	Answer
1.1	As Principal Investigator of this single/multisite research study, I acknowledge that	I agree to monitor progress and oversee the overall conduct of the study at all participating sites.|I will ensure that all authorized participating site investigators and study team members are appropriately qualified and are adequately trained and knowledgeable on their study-related duties and institutional HRPP Standard Operating Pocedures will adhere to the NS Health REB approved protocol contained within this application.|I will act as the primary contact liaison with outside regulatory agencies, REB representatives, and authorized participating sites. When appropriate or necessary, I will delegate this authority in writing in a delegation log in my study files.|I am responsible to adhere to the NS Health REB approved protocol, and its subsequent amendments including amendments to supporting research materials listed within this application (e.g. Waiver of Consent Addendum). As PI, it is my responsibility to ensure that all authorized participating sites, study team members, and investigators listed on this application form are using the correct version of the protocol, its approved attachments and supporting materials. |I commit to selecting qualified sites and qualified personnel according to applicable regulations at each site for participation in the research as described in this application to the NS Health REB, as well as NS Health Privacy.|I confirm that I am responsible for all communications with the study sponsor (when applicable).|I will conduct the study in accordance with this application and all applicable policies, procedures, standards, regulations and/or legislation including, but not limited to, the REB and Privacy Office requirements, NS Health policies and procedures, Nova Scotia's Personal Health Information Act (PHIA) and Personal Information International Disclosure Protection Act (PIIDPA), the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2), and the Belmont Report. |I will conduct the study in accordance with the REB approved application, protocol, and all applicable standards (e.g. REB requirements, applicable institutional policies and procedures, Nova Scotia's Personal Health Information Act (PHIA) and Personal

		Information International Disclosure Protection Act (PIIDPA), the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2), and the Belmont Report. |I am responsible for the analysis, reporting, integrity, and accuracy of the study data. |I will comply with any terms and conditions imposed by the NS Health REB and NS Health.|I will take appropriate measures to safeguard the study data and take appropriate steps to prevent unauthorized use or disclosure of the study data, Personal Information and Personal Health Information as defined in PHIA (PI and PHI). |I will retain these records in accordance with NS Health and NS Health REB Standard Operating Procedures. If requested, I will assist NS Health and the NS Health REB with concerns or complaints reported by study participants and/or others with lawful requests to access study data.|I will use PI and PHI only for purposes outlined in this application and as approved by the NS Health REB, and where applicable, the NS Health Privacy Office.|I will limit the use of PI and PHI to the minimum amount necessary and in the most de-identified form possible.|I will not attempt to identify or contact individuals without their prior consent, unless otherwise authorized by the NS Health REB and NS Health.|I will not publish information in a form where it is reasonably foreseeable in the circumstances that it could be utilized, either alone or with other information, to identify an individual, except with the individual's express consent.|I will allow the authorized participating sites, NS Health and/or the NS Health REB to access, audit, and/or inspect the research premises to confirm that the research complies with these terms, applicable policies, procedures, standards, regulations and/or legislation|I will notify authorized participating sites, the NS Health Privacy Office, and the NS Health REB immediately and in writing if PI and/or PHI is stolen, lost, or subject to unauthorized access, use, disclosure, copying or modification. This includes known or suspected breaches of applicable agreements.
1.2	This attestation was modified and updated on June 15, 2022. All applications submitted to the REB after June 15, 2022 will be subject to this new attestation. All applications submitted prior to this date will continue to be subject to the prior attestation. The prior attestation will	

	be retained by the NS Health Research Ethics Office. Addendum: Sept 15, 2022	

2. Administrative Information

#	Question	Answer
2.1	PI's Institutional Affiliation(s)	NSHA/Dalhousie university/Memorial University
2.2	PI'S Nova Scotia Health Zone	Zone 4 - Central
2.3	Is this research interdisciplinary (eg. Research is considered interdisciplinary if it is involving investigators/sub-investigators from two or more departments, divisions, programs or services)?	Yes
2.4	Is this research:	Investigator Driven (Sponsored)
2.5	If Investigator driven, is it led:	Locally
2.6	If Investigator driven externally, specify name & institution. (Please list full contact information)	
2.7	If Industry driven (sponsored), specify. (Please list full contact information).	
2.8	Is the PI a trainee or not affiliated with NS Health (e.g. student, resident, fellow, external researcher)?	Yes (A NSHA Affiliate Supervising Investigator is required if the PI is a trainee or has no NSHA affiliation)
2.9	Has funding been obtained for this study? *NOTE: If your study is industry-driven (sponsored) AND industry-funded (contract) you are required to submit the Invoice for REB Review with your submission.	Unfunded
2.10	If your study is/will be funded, specify the company/granting agency/foundation, government department, or other source of funding, etcetera. (please include the city, state, and country of the study sponsor)	
2.11	If applicable, where will the research account be held?	NSHA
2.12	What does this study involve? (select all that apply)	Questionnaire(s)|Qualitative|Quantitative
2.13	Has this study been reviewed by a committee, department, or division of a participating institution?	No
2.14	Has this study been reviewed externally (e.g. by funding agencies or other academic institutions/organizations)?	No

2.15	Has this study been submitted to another research ethics board?	No
2.16	If you previously answered yes or pending (questions 2.13, 2.14 and/or 2.15), what REB and other review body have you submitted to and what is the status/response of the application? Please attach the reviewer comments to this application.	

3. Research Summary

#	Question	Answer
3.1	Outline the background and rationale of the research study. Why is the research important?	Enhanced recovery after surgery (ERAS) is a protocol designed to improve patient outcomes and expedite recovery following surgery, and is well established in many fields, such as colorectal and gynecologic surgery. Currently, no ERAS guidelines are present for spine surgery. Two major components of developing a spine ERAS protocol involve pre-operative patient education, and recognizing what factors are keeping patients in hospital following surgery. This study aims to see what factors following elective spine surgery for degenerative lumbar and cervical conditions keep patients in hospital. This research will allow the division of neurosurgery to improve patient education by identifying what factors commonly keep patients in hospital. Furthermore, by identifying these factors, this allows healthcare staff to adjust post-operative care of the patient to better facilitate their recovery.
3.2	What is the hypothesis to be tested/question to be asked?	What factors, post-operatively, following elective spine surgery for degenerative conditions of the lumbar and cervical spine prevent patients from being discharged? A secondary objective is to examine differences between what a healthcare provider determines deems why a patient is still in hospital following elective spine surgery, and why patients think they are still in hospital.
3.3	Describe the study methodology (including study design).	This study will be primarily descriptive and qualitative and data will be collected prospectively. All patients from February 1st, 2021 until July 31st, 2021 who undergo an elective posterior cervical or lumbar decompression and fusion for a degenerative condition will be included. Twice daily, the charge nurse on 7.3 in the Halifax Infirmary will be asked why patients who meet the above

		criteria are still in hospital. Possible options for failure to discharge include: Pain management, dizziness, confusion, sedation, post-op nausea/vomiting, urinary retention, muscle weakness, technical reasons, logistic reasons, or other. Patients will also be interviewed each day, asking why they believe they are still in hospital.
3.4	What are the outcome measures/study objectives?	The first outcome measure is what factors are most commonly keeping patients in hospital following spine surgery. Potential factors contributing to keeping patients in hospital include: Pain management, dizziness, confusion, sedation, post-op nausea/vomiting, urinary retention, muscle weakness, technical reasons, logistic reasons, or other. Demographic characteristics (such as age, BMI, sex, geographic location, etc) will then also be used to determine if those variables are predictive in associated barriers. For example, if a patient lives on their own or far away from the Halifax Infirmary, are they more likely to have issues regarding logistic factors.
3.5	How will the data be analyzed?	Reason for why a patient is still in hospital will be reported as frequencies and percentages. Continuous variables will be compared through a one-way ANOVA or the Mann-Whitney U test if necessary. Categorical variables will be compared with the chi-square test for proportion. Significance will be taken at p=0.05 level.
3.6	What are the proposed benefits and potential harms of this research, and how do the benefits outweigh the harms?	Potential benefits include better targeted care for patients while they recover from surgery. Another benefit is that this study will help us improve patient education pre-operatively. There are no known potential harms to this study.
3.7	What is the expected duration of the study?	This study is expected to last 8 months. The first 6 months will be used for data collection, while the remaining two months will be for analyzing data and determining the results. It is expected that the final results of this study will be made public through a journal article within 2 years of the study starting.
3.8	Does the trial include any optional sub-studies?	No
3.9	If the trial includes optional sub-studies, please specify the type(s) of sub-study(ies) that your site will be participating in (tick all that apply):	

3.10	If you selected 'other,' please specify the type of sub-study.	
3.11	For each of the optional sub-studies your site plans to participate in: describe the sub-study; outline the background and rationale of the study; describe the proposed benefits and potential harms associated with each sub-study and explain how the benefits outweigh the harms.	

4. Research Protocol Information

#	Question	Answer
4.1	Where specifically will the research be conducted? (e.g. QEII HSC, Specialty Clinic, etc.)	Halifax Infirmary
4.2	What is the maximum number of local participants you plan to enroll?	This study will examine all patients who meet our inclusion criteria for the 6 month period that data collection is ongoing. It is anticipated approximately 200 people will be recruited.
4.3	What is the maximum number of participants to be enrolled globally (include local participants)?	200
4.4	Are there any exclusion criteria that appear to violate the principle of inclusiveness (e.g. upper/lower age limit, exclusion of women)?	Yes
4.5	If yes, provide justification for these exclusion criteria.	The age limit is for patients 18 years of age and older. This is because patients in hospital on 7.3 at the Halifax Infirmary will be at least 18 years of age or older.
4.6	Will study activities deviate from usual care at NS Health?	No
4.7	If yes, describe any procedures, research activities, or other interventions that would normally not be conducted in the course of usual care at NS Health.	
4.8	Does anything in the protocol or the research agreement limit your ability to notify research participants, other investigators, physicians, the REB, regulatory agencies and/or the scientific community of risks identified during the conduct of the study?	No
4.9	If yes, provide details.	
4.10	Describe any systems/supports in place to assist participants who become distressed due to study participation.	N/A

5. Compensation / Conflict of Interest

#	Question	Answer
5.1	Will participants be reimbursed for expenses (e.g., mileage, parking, meal vouchers, child care, etc.)?	No
5.2	If yes, what is the amount of compensation and provide details explaining why the amount of compensation is justified.	
5.3	Will participants be provided with any additional compensation?	No
5.4	If yes, provide details explaining why the amount of additional compensation is justified.	
5.5	Will honoraria or any other incentives be provided to the research team or other parties involved in the study?	No
5.6	If yes, list the honoraria/incentives.	
5.7	Do any of the participating institutions and/or investigators have a financial or proprietary interest in the research and/or the product under investigation and/or the sponsor or funder(s) of the research?	No
5.8	If Yes, provide details and explain how the potential conflict will be addressed.	
5.9	Are you aware of any other actual or perceived conflicts of interest on the part of the participating institutions or the investigators?	No
5.10	If Yes, provide details and explain how the potential conflict will be addressed.	

6. Participant Identification and Informed Consent

#	Question	Answer
6.1	Describe the participant population to be studied.	This population involves all patients who are aged 18 and older, and are undergoing scheduled posterior cervical or lumbar decompression and fusion procedures. Patients undergoing surgery for deformity or tumor will be excluded.
6.2	Does your study include a cohort of vulnerable populations or communities (i.e. First Nations, African Nova Scotian, Immigrants, etc)	No
6.3	If YES, please describe the process you undertook to engage the relevant community?	
6.4	Have you attached all pertinent documentation from the community engagement process such as research agreements and ethics approval?	N/A

6.5	How will potential participants be recruited or how will charts be selected?	All patients who undergo scheduled posterior cervical or lumbar decompression and fusion procedures from January 1st, 2021 to June 30th, 2021 will be included. The charge nurse on 7.3 will be asked twice daily (at 10am and 3pm) what top two factors are keeping a patient in hospital. Patients who meet the inclusion criteria will be identified by a spine surgeon (a sub-investigator) and the principal investigator or a research coordinator will describe the study to the patient and will consent them if they choose to participate.
6.6	Have / will individuals consent to having their personal health information accessed for recruitment purposes?	Yes (Have individuals signed the Access to Personal Health Information Consent Form and/or do you have an approved SOP to allow access to Personal Health Information under Circle of Care)
6.7	If yes, describe how this consent has been or will be obtained.	The Spine surgeons (Principal investigator or subinvestigators) will be accessing the PHI within the circle of care. The spine surgeons will collect, use or disclose Personal Health Information (PHI) for the primary therapeutic benefit of the patient and only on their determination will the patient then be asked if they wish to discus the research study.
6.8	Who will initially approach potential participants regarding the study? List roles rather than names of people (e.g. research coordinator) and what training they have or will receive on how to solicit consent from potential participants.	The sub-investigator will approach the patient about the study, and the principal investigator or research coordinator will describe the study and provide informed consent.
6.9	Will individuals be asked to consent to study participation?	Yes, complete the rest of the questions in this section
6.10	Who will conduct the informed consent discussion(s)? List roles rather than names of people (e.g. research coordinator).	The principal investigator or a research coordinator will conduct informed consent. A spine surgeon (sub-investigator) will first make sure the patient meets all inclusion criteria.
6.11	Do you have a written procedure (SOP) for obtaining consent?	Yes, SOP for obtaining consent is attached
6.12	If no, describe your process for obtaining informed consent.	
6.13	Will study participants be asked to participate in an optional sub-study(ies)?	No, participants will not be asked to participate in an optional sub-study(ies)
6.14	Will you enroll study participants (or their substitute decision-makers) who may be unable to read the consent form or other study materials?	Yes
6.15	Do you anticipate that study participants may lack capacity to provide informed consent?	No

6.16	If yes, describe the anticipated nature/circumstances of this lack of capacity.	
6.17	How will the team assess participants' capacity to provide informed consent for this study?	The principal investigator or research coordinator will ask the patient questions determining if they understand the study and what their involvement will entail.
6.18	What will you do if a participant lacks capacity to provide informed consent?	Disqualify the participant from the study
6.19	What will be done if the participant loses capacity to provide informed consent during the study?	Seek informed consent from the participant's substitute decision maker

7. Privacy and Confidentiality

#	Question	Answer
7.1	Will any personal health information (PHI) be collected or used to conduct the research or identify potential participants? (See description for definition)	Yes
7.2	List all the PHI and /or Personal Information (PI) (e.g. human study data/variables) required to conduct the research, including PHI/PI from associated sub-studies. List any PHI/PI needed to identify potential participants.	Patient age, BMI, smoking status, sex, education, living arrangement, geographic location (based on first 3 alphanumeric digits of their postal code), marital status and ASA grade and comorbidities will be recorded. Participants will be identified based on their pathology and procedure that they will receive for surgery.
7.3	Identify potential sources of this information (e.g., participants themselves, health records, databases, third parties).	Health records and participants themselves.
7.4	How will the personal health information be used in the research?	Patient age, BMI, smoking status, sex, education, living arrangement, geographic location, marital status and ASA grade will all be used to see if any of these factors are predictive in determining a reason why a patient may still be in hospital.
7.5	Explain why the research could not reasonably be accomplished without using the personal health information.	Without this information, we cannot tailor care offered on 7.3 to these patients. This information will allow healthcare staff to target care based on the patients demographic characteristics.
7.6	Will personal health information maintained by the institution(s) be combined with personal information from other sources to form a composite record (data linkage)?	No
7.7	If yes, describe the other personal information and its source(s) and how the linkage will be conducted.	

7.8	Will the personal health information be used in the most de-identified form possible for the conduct of the research?	Yes
7.9	Please comment, and explain how any de-identification will be performed.	Patient identification numbers will be assigned to each patient, where only the patient ID will be used when collecting data or when analyzing it.
7.10	Describe reasonably foreseeable risks arising from the use of the personal health information and how these risks will be mitigated. (Privacy Breach)	Only the Principal Investigator, Supervising investigator, Research Coordinator(s) will have access to the personal health information. All others responsible for reviewing and analyzing the data will only have access to de-identified data.
7.11	If applicable, describe any other safeguards and risk mitigation measures to protect personal health information from unauthorized collection, use and disclosure.	De-identified data will be maintained in a password-protected database on a password-protected Nova Scotia Health Authority (NSHA) computer in a locked office. Study documents are kept securely with the research locked office. The research office is locked at all times and only research team members have access to this office. The research office is located in the Abbie J. Lane Building, room 3068. All study personnel are bound by NSHA privacy and confidentiality policies.
7.12	Will personal health information (PHI) be accessed for study purposes?	Yes
7.13	If PHI will be accessed for study purposes, who will have access to the PHI? Tick all that apply.	Principal Investigator |Supervising Investigator |Research coordinator(s)
7.14	List any additional study roles (not mentioned in the previous list) that will be accessing PHI for study purposes.	
7.15	For each individual role (e.g. PI, Sponsor, coordinator, etc.) that will have access to the PHI, explain why their access is necessary, and list their qualifications (see description for definition).	PI: Ryan Greene is a PhD student in the Faculty of Medicine (Clinical Epidemiology) at Memorial University of Newfoundland and a research coordinator in the Division of Neurosurgery at Nova Scotia Health. Ryan possesses his Master of Science in Medicine (Clinical Epidemiology) and will be collecting data for reasons why a patient isn't discharged, and will also be building the database used for the analysis. Ryan will also be performing all statistical analysis for the study. Supervising Investigator: Dr. Sean Christie is a spine neurosurgeon at the Halifax Infirmary. Dr. Christie is also a co-supervisor for Ryan Greene for his PhD studies.
7.16	Describe administrative, physical and technical measures to be taken to safeguard the personal health information and study data.	The research is locked at all times and only research team members involved in the study have access to the research office where the

		data will be stored. Each subject has their own study ID which will keep them de-identified in the database. All study documents are stored on a password protected computer, which only research staff involved have access. Computers are password protected and are kept behind the NSHA firewall.
7.17	Where and how will personal health information and study data be stored during the course of the study (while it is active)?	All data will be stored on password protected computers in the research office, which is locked and only members of the research team will have access to.The research office is located in the Abbie J. Lane Building, room 3068. Furthermore, all participants will be de-identified with their own study ID number in the database.
7.18	Will participant information be transferred to parties outside the Nova Scotia Health Authority (e.g., identifying or de-identified study data, lab requisitions/results, EKG or X-ray reports, discharge summaries, survey results)?	No
7.19	If yes, which information will be transferred? To whom, to where, and how will the information be transferred?	
7.20	If yes, explain how information will be de-identified or (in the case of identifying information) how participant permission will be obtained.	
7.21	Is the transfer covered in the research agreement or in a data transfer agreement?	Not applicable
7.22	Will researchers' personal information be transferred to parties who may store or access the information outside Canada?	No
7.23	If yes, how will the individuals' consent be obtained and recorded?	
7.24	If yes, describe any measures taken to minimize and protect the personal information (e.g. abbreviated CVs).	
7.25	Where and how will research records be stored after study closure?	Research records will be transferred to Research Services, Central Zone, NSHA for long term storage per our institutional policy.
7.26	How long will these records be stored?	7 years
7.27	How and by whom will the records be securely destroyed, permanently erased (ie IT) and/or de-identified at the end of the retention period?	Research Services will arrange for the destruction in accordance with the applicable standards.
7.28	Will interviews or focus groups be conducted?	Yes

7.29	If yes, will sessions be recorded?	No
7.30	If yes, will participants be asked to review transcriptions for accuracy?	No
7.31	Will survey software be used?	No
7.32	If survey software will be used, which vendor(s) will be used and where will the servers be located? (Must be in Canada)	
7.33	Will there be data matching?	No
7.34	If yes, explain why data matching is required.	

8. Other Ethical Issues

#	Question	Answer
8.1	Are you aware of any other ethical issues regarding the design or conduct of the study (i.e. blinding)?	No
8.2	If yes, describe the issues and explain how they will be addressed.	

Attachments

Doc / Agreement	Version Date	File Name	Description
Approval Letter - REB Use Only	2021/03/04	DR1026525final.docx	N/A
Certificate of Completion TCPS 2: CORE	2023/06/01	tcps2_core_certificate.pdf	RDG TCPS2: June 1 2023
Consent Form - paper version	2021/03/02	consent-non-interventional-studies-March 2 2021 Version 1.3.doc	Informed Consent form Version 1.3- March 2, 2021
Renewal - REB Use Only	2024/02/26		March 4, 2024 - March 4, 2025

Research Protocol	2021/01/15	Barriers to Discharge Protocol January 15 2021.docx	Research Protocol Version 1.0
Supporting Materials	2020/11/03	Barriers to Discharge List November 3 2020.docx	Data Collection Sheet
Supporting Materials	2021/01/15	Pre-Operative Data Collection.docx	Pre-Operative Data Collection Form
Certificate of Completion TCPS 2: CORE	2012/02/17	Dr.Christie TCPS2 Feb 17 2012.pdf	SI TCPS2
Certificate of Completion TCPS 2: CORE	2017/04/12	tcps2_core_certificate Ryan Greene.pdf	TCPS2 PI
Consent Form - paper version	2021/01/13	consent-non-interventional-studies-Jan 13 2021.doc	Non-Interventional Study Informed Consent
Consent Form - paper version	2021/02/23	consent-non-interventional-studies-February 23 2021 Version 1.1.docx	Informed consent Form Version 1.1-February 23, 2021
Curriculum Vitae (CV)	2020/11/20	CCV-SeanChristie-CIHR_Biosketch (5-pages-spine).pdf	SI CV
Curriculum Vitae (CV)		Ryan D Greene CV.docx	PI CV
Curriculum Vitae (CV)	2021/02/23	Ryan D Greene CV Signed.pdf	PI Ryan Greene CV Signed-February 23, 2021
Initial Letter - REB Use Only	2021/02/02	DR1026525IL.docx	N/A

Investigator Response/Revisions	2021/02/24	Cover Letter-Barriers To Discharge Study 1026525.docx	Cover Letter-February 24, 2021
Investigator Response/Revisions	2021/03/02	Cover Letter-Barriers To Discharge Study 1026525 March 2 2021.docx	Cover Letter-March 2, 2021
Letter of Support	2021/01/07	2021 01 07 SI and PI Letter of Support.pdf	PI and SI letters of Support
Renewal - REB Use Only	2022/03/28		Mar 04, 2022-Mar 04, 2023
Renewal - REB Use Only	2023/02/10		Mar 4, 2023-Mar 4, 2024
Researcher's Checklist for Submission	2021/01/15	researchers-checklist-submissions-non-interventional-2021 01 15.doc	Researcher Checklist
Researcher's Commitment Form	2020/12/16	researchers-commitments-supervising-investigator-2020-04-30.pdf	SI Commitments
SOP	2018/11/29	SOP 15 (a) signed.pdf	SOP 15 Obtaining Consent
SOP	2018/11/29	SOP 14 signed.pdf	SOP 14 Screening

Nova Scotia Health NON-INTERVENTIONAL STUDY - Ethics Application Form (EAF)

Project Info.

File No: 1026525
Project Title: What factors prevent patients being discharged from hospital after major spine surgery?
Principal Investigator: Mr. Ryan Greene (Medicine\Surgery\Neurosurgery)
Start Date: 2021/03/04
End Date:

Keywords: Spine surgery, Spine, , Assessing Barriers, Neurosurgery

Question	Answer
Clinical Trials No.	

Project Team Info.

Principal Investigator

Prefix: Mr.
Last Name: Greene
First Name: Ryan
Affiliation: Medicine\Surgery\Neurosurgery
Position: PhD Student
Email: ryan.greene@nshealth.ca
Phone1: 902-473-3877
Phone2: 902-754-3337
Fax: 902-425-2620
Primary Address: Queen Elizabeth II HSC Room 3068, AJL Building 5909 Veterans Memorial Lane Halifax, Nova Scotia, B3H 2E2
Institution: Memorial University of Newfoundland
Country: Canada
Comments: I am currently a PhD student at Memorial University of Newfoundland, and a research coordinator in the Division of Neurosurgery for Nova Scotia Health. Team members from Memorial University of Newfoundland include: Dr. Amanda Hall | Sub-Investigator | Memorial University of Newfoundland Dr. Holly Etchegary | Sub-Investigator | Memorial University of Newfoundland

Other Project Team Members

Prefix	Last Name	First Name	Affiliation	Role In Project	Email
Mrs.	Julien	Lisa	Medicine\Surgery\Neurosurgery	Research Coordinator	lisa.julien@nshealth.ca
Dr.	Christie	Sean	Medicine\Surgery\Neurosurgery	Supervising Investigator	sean.christie@dal.ca

Dr.	Oxner	William	Medicine\Surgery	Sub-Investigator	WOXNER@DAL.CA
Dr.	Alant	Jacob	Medicine\Surgery\Neurosurgery	Sub-Investigator	jacob.alant@nshealth.ca
Dr.	Barry	Sean	Medicine\Surgery\Neurosurgery	Sub-Investigator	barrysp@cdha.nshealth.ca
Dr.	Glennie	Raymond (Andrew)	Medicine\Surgery\Orthopedic Surgery	Sub-Investigator	andrew.glennie@nshealth.ca

Common Questions

1. Principal Investigator Attestation/Commitments

#	Question	Answer
1.1	As Principal Investigator of this single/multisite research study, I acknowledge that	I agree to monitor progress and oversee the overall conduct of the study at all participating sites.|I will ensure that all authorized participating site investigators and study team members are appropriately qualified and are adequately trained and knowledgeable on their study-related duties and institutional HRPP Standard Operating Pocedures will adhere to the NS Health REB approved protocol contained within this application.|I will act as the primary contact liaison with outside regulatory agencies, REB representatives, and authorized participating sites. When appropriate or necessary, I will delegate this authority in writing in a delegation log in my study files.|I am responsible to adhere to the NS Health REB approved protocol, and its subsequent amendments including amendments to supporting research materials listed within this application (e.g. Waiver of Consent Addendum). As PI, it is my responsibility to ensure that all authorized participating sites, study team members, and investigators listed on this application form are using the correct version of the protocol, its

		approved attachments and supporting materials. |I commit to selecting qualified sites and qualified personnel according to applicable regulations at each site for participation in the research as described in this application to the NS Health REB, as well as NS Health Privacy.|I confirm that I am responsible for all communications with the study sponsor (when applicable).|I will conduct the study in accordance with this application and all applicable policies, procedures, standards, regulations and/or legislation including, but not limited to, the REB and Privacy Office requirements, NS Health policies and procedures, Nova Scotia's Personal Health Information Act (PHIA) and Personal Information International Disclosure Protection Act (PIIDPA), the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2), and the Belmont Report. |I will conduct the study in accordance with the REB approved application, protocol, and all applicable standards (e.g. REB requirements, applicable institutional policies and procedures, Nova Scotia's Personal Health Information Act (PHIA) and Personal Information International Disclosure Protection Act (PIIDPA), the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2), and the Belmont Report. |I am responsible for the analysis, reporting, integrity, and accuracy of the study data. |I will comply with any terms and conditions imposed by the NS Health REB and NS Health.|I will take appropriate measures to safeguard the study data and take appropriate steps to prevent unauthorized use or disclosure of the study data, Personal Information and Personal Health Information as defined in PHIA (PI and PHI). |I will retain these records in accordance with NS Health and NS Health REB Standard Operating Procedures. If requested, I will assist NS Health and the NS Health REB with concerns or complaints reported by study participants and/or others with lawful requests to access study data.|I will use PI and PHI only for purposes outlined in this application and as approved by the NS Health REB, and where applicable, the NS Health Privacy Office.|I will limit the use of PI and PHI to the minimum amount necessary and in the most de-identified form possible.|I will not attempt to identify or contact individuals

		without their prior consent, unless otherwise authorized by the NS Health REB and NS Health.|I will not publish information in a form where it is reasonably foreseeable in the circumstances that it could be utilized, either alone or with other information, to identify an individual, except with the individual's express consent.|I will allow the authorized participating sites, NS Health and/or the NS Health REB to access, audit, and/or inspect the research premises to confirm that the research complies with these terms, applicable policies, procedures, standards, regulations and/or legislation|I will notify authorized participating sites, the NS Health Privacy Office, and the NS Health REB immediately and in writing if PI and/or PHI is stolen, lost, or subject to unauthorized access, use, disclosure, copying or modification. This includes known or suspected breaches of applicable agreements.
1.2	This attestation was modified and updated on June 15, 2022. All applications submitted to the REB after June 15, 2022 will be subject to this new attestation. All applications submitted prior to this date will continue to be subject to the prior attestation. The prior attestation will be retained by the NS Health Research Ethics Office. Addendum: Sept 15, 2022	

2. Administrative Information

#	Question	Answer
2.1	PI's Institutional Affiliation(s)	NSHA/Dalhousie university/Memorial University
2.2	PI'S Nova Scotia Health Zone	Zone 4 - Central
2.3	Is this research interdisciplinary (eg. Research is considered interdisciplinary if it is involving investigators/sub-investigators from two or more departments, divisions, programs or services)?	Yes
2.4	Is this research:	Investigator Driven (Sponsored)
2.5	If Investigator driven, is it led:	Locally
2.6	If Investigator driven externally, specify name & institution. (Please list full contact information)	
2.7	If Industry driven (sponsored), specify. (Please list full contact information).	

2.8	Is the PI a trainee or not affiliated with NS Health (e.g. student, resident, fellow, external researcher)?	Yes (A NSHA Affiliate Supervising Investigator is required if the PI is a trainee or has no NSHA affiliation)
2.9	Has funding been obtained for this study? *NOTE: If your study is industry-driven (sponsored) AND industry-funded (contract) you are required to submit the Invoice for REB Review with your submission.	Unfunded
2.10	If your study is/will be funded, specify the company/granting agency/foundation, government department, or other source of funding, etcetera. (please include the city, state, and country of the study sponsor)	
2.11	If applicable, where will the research account be held?	NSHA
2.12	What does this study involve? (select all that apply)	Questionnaire(s)|Qualitative|Quantitative
2.13	Has this study been reviewed by a committee, department, or division of a participating institution?	No
2.14	Has this study been reviewed externally (e.g. by funding agencies or other academic institutions/organizations)?	No
2.15	Has this study been submitted to another research ethics board?	No
2.16	If you previously answered yes or pending (questions 2.13, 2.14 and/or 2.15), what REB and other review body have you submitted to and what is the status/response of the application? Please attach the reviewer comments to this application.	

3. Research Summary

#	Question	Answer
3.1	Outline the background and rationale of the research study. Why is the research important?	Enhanced recovery after surgery (ERAS) is a protocol designed to improve patient outcomes and expedite recovery following surgery, and is well established in many fields, such as colorectal and gynecologic surgery. Currently, no ERAS guidelines are present for spine surgery. Two major components of developing a spine ERAS protocol involve pre-operative patient education, and recognizing what factors are keeping patients in hospital following surgery. This study aims to see what factors following elective spine surgery for degenerative lumbar and cervical conditions keep patients in hospital. This research will

		allow the division of neurosurgery to improve patient education by identifying what factors commonly keep patients in hospital. Furthermore, by identifying these factors, this allows healthcare staff to adjust post-operative care of the patient to better facilitate their recovery.
3.2	What is the hypothesis to be tested/question to be asked?	What factors, post-operatively, following elective spine surgery for degenerative conditions of the lumbar and cervical spine prevent patients from being discharged? A secondary objective is to examine differences between what a healthcare provider determines deems why a patient is still in hospital following elective spine surgery, and why patients think they are still in hospital.
3.3	Describe the study methodology (including study design).	This study will be primarily descriptive and qualitative and data will be collected prospectively. All patients from February 1st, 2021 until July 31st, 2021 who undergo an elective posterior cervical or lumbar decompression and fusion for a degenerative condition will be included. Twice daily, the charge nurse on 7.3 in the Halifax Infirmary will be asked why patients who meet the above criteria are still in hospital. Possible options for failure to discharge include: Pain management, dizziness, confusion, sedation, post-op nausea/vomiting, urinary retention, muscle weakness, technical reasons, logistic reasons, or other. Patients will also be interviewed each day, asking why they believe they are still in hospital.
3.4	What are the outcome measures/study objectives?	The first outcome measure is what factors are most commonly keeping patients in hospital following spine surgery. Potential factors contributing to keeping patients in hospital include: Pain management, dizziness, confusion, sedation, post-op nausea/vomiting, urinary retention, muscle weakness, technical reasons, logistic reasons, or other. Demographic characteristics (such as age, BMI, sex, geographic location, etc) will then also be used to determine if those variables are predictive in associated barriers. For example, if a patient lives on their own or far away from the Halifax Infirmary, are they more likely to have issues regarding logistic factors.
3.5	How will the data be analyzed?	Reason for why a patient is still in hospital will be reported as frequencies and percentages. Continuous variables will be compared through

		a one-way ANOVA or the Mann-Whitney U test if necessary. Categorical variables will be compared with the chi-square test for proportion. Significance will be taken at p=0.05 level.
3.6	What are the proposed benefits and potential harms of this research, and how do the benefits outweigh the harms?	Potential benefits include better targeted care for patients while they recover from surgery. Another benefit is that this study will help us improve patient education pre-operatively. There are no known potential harms to this study.
3.7	What is the expected duration of the study?	This study is expected to last 8 months. The first 6 months will be used for data collection, while the remaining two months will be for analyzing data and determining the results. It is expected that the final results of this study will be made public through a journal article within 2 years of the study starting.
3.8	Does the trial include any optional sub-studies?	No
3.9	If the trial includes optional sub-studies, please specify the type(s) of sub-study(ies) that your site will be participating in (tick all that apply):	
3.10	If you selected 'other,' please specify the type of sub-study.	
3.11	For each of the optional sub-studies your site plans to participate in: describe the sub-study; outline the background and rationale of the study; describe the proposed benefits and potential harms associated with each sub-study and explain how the benefits outweigh the harms.	

4. Research Protocol Information

#	Question	Answer
4.1	Where specifically will the research be conducted? (e.g. QEII HSC, Specialty Clinic, etc.)	Halifax Infirmary
4.2	What is the maximum number of local participants you plan to enroll?	This study will examine all patients who meet our inclusion criteria for the 6 month period that data collection is ongoing. It is anticipated approximately 200 people will be recruited.
4.3	What is the maximum number of participants to be enrolled globally (include local participants)?	200
4.4	Are there any exclusion criteria that appear to violate the principle of inclusiveness (e.g. upper/lower age limit, exclusion of women)?	Yes

4.5	If yes, provide justification for these exclusion criteria.	The age limit is for patients 18 years of age and older. This is because patients in hospital on 7.3 at the Halifax Infirmary will be at least 18 years of age or older.
4.6	Will study activities deviate from usual care at NS Health?	No
4.7	If yes, describe any procedures, research activities, or other interventions that would normally not be conducted in the course of usual care at NS Health.	
4.8	Does anything in the protocol or the research agreement limit your ability to notify research participants, other investigators, physicians, the REB, regulatory agencies and/or the scientific community of risks identified during the conduct of the study?	No
4.9	If yes, provide details.	
4.10	Describe any systems/supports in place to assist participants who become distressed due to study participation.	N/A

5. Compensation / Conflict of Interest

#	Question	Answer
5.1	Will participants be reimbursed for expenses (e.g., mileage, parking, meal vouchers, child care, etc.)?	No
5.2	If yes, what is the amount of compensation and provide details explaining why the amount of compensation is justified.	
5.3	Will participants be provided with any additional compensation?	No
5.4	If yes, provide details explaining why the amount of additional compensation is justified.	
5.5	Will honoraria or any other incentives be provided to the research team or other parties involved in the study?	No
5.6	If yes, list the honoraria/incentives.	
5.7	Do any of the participating institutions and/or investigators have a financial or proprietary interest in the research and/or the product under investigation and/or the sponsor or funder(s) of the research?	No
5.8	If Yes, provide details and explain how the potential conflict will be addressed.	

5.9	Are you aware of any other actual or perceived conflicts of interest on the part of the participating institutions or the investigators?	No
5.10	If Yes, provide details and explain how the potential conflict will be addressed.	

6. Participant Identification and Informed Consent

#	Question	Answer
6.1	Describe the participant population to be studied.	This population involves all patients who are aged 18 and older, and are undergoing scheduled posterior cervical or lumbar decompression and fusion procedures. Patients undergoing surgery for deformity or tumor will be excluded.
6.2	Does your study include a cohort of vulnerable populations or communities (i.e. First Nations, African Nova Scotian, Immigrants, etc)	No
6.3	If YES, please describe the process you undertook to engage the relevant community?	
6.4	Have you attached all pertinent documentation from the community engagement process such as research agreements and ethics approval?	N/A
6.5	How will potential participants be recruited or how will charts be selected?	All patients who undergo scheduled posterior cervical or lumbar decompression and fusion procedures from January 1st, 2021 to June 30th, 2021 will be included. The charge nurse on 7.3 will be asked twice daily (at 10am and 3pm) what top two factors are keeping a patient in hospital. Patients who meet the inclusion criteria will be identified by a spine surgeon (a sub-investigator) and the principal investigator or a research coordinator will describe the study to the patient and will consent them if they choose to participate.
6.6	Have / will individuals consent to having their personal health information accessed for recruitment purposes?	Yes (Have individuals signed the Access to Personal Health Information Consent Form and/or do you have an approved SOP to allow access to Personal Health Information under Circle of Care)
6.7	If yes, describe how this consent has been or will be obtained.	The Spine surgeons (Principal investigator or subinvestigators) will be accessing the PHI within the circle of care. The spine surgeons will collect, use or disclose Personal Health Information (PHI) for the primary therapeutic benefit of the patient and only on their determination will the patient then be asked if they wish to discus the research study.

6.8	Who will initially approach potential participants regarding the study? List roles rather than names of people (e.g. research coordinator) and what training they have or will receive on how to solicit consent from potential participants.	The sub-investigator will approach the patient about the study, and the principal investigator or research coordinator will describe the study and provide informed consent.
6.9	Will individuals be asked to consent to study participation?	Yes, complete the rest of the questions in this section
6.10	Who will conduct the informed consent discussion(s)? List roles rather than names of people (e.g. research coordinator).	The principal investigator or a research coordinator will conduct informed consent. A spine surgeon (sub-investigator) will first make sure the patient meets all inclusion criteria.
6.11	Do you have a written procedure (SOP) for obtaining consent?	Yes, SOP for obtaining consent is attached
6.12	If no, describe your process for obtaining informed consent.	
6.13	Will study participants be asked to participate in an optional sub-study(ies)?	No, participants will not be asked to participate in an optional sub-study(ies)
6.14	Will you enroll study participants (or their substitute decision-makers) who may be unable to read the consent form or other study materials?	Yes
6.15	Do you anticipate that study participants may lack capacity to provide informed consent?	No
6.16	If yes, describe the anticipated nature/circumstances of this lack of capacity.	
6.17	How will the team assess participants' capacity to provide informed consent for this study?	The principal investigator or research coordinator will ask the patient questions determining if they understand the study and what their involvement will entail.
6.18	What will you do if a participant lacks capacity to provide informed consent?	Disqualify the participant from the study
6.19	What will be done if the participant loses capacity to provide informed consent during the study?	Seek informed consent from the participant's substitute decision maker

7. Privacy and Confidentiality

#	Question	Answer
7.1	Will any personal health information (PHI) be collected or used to conduct the research or identify potential participants? (See description for definition)	Yes
7.2	List all the PHI and /or Personal Information (PI) (e.g. human study data/variables) required to conduct the research, including PHI/PI from	Patient age, BMI, smoking status, sex, education, living arrangement, geographic location (based on first 3 alphanumeric digits of their postal code), marital status and ASA

	associated sub-studies. List any PHI/PI needed to identify potential participants.	grade and comorbidities will be recorded. Participants will be identified based on their pathology and procedure that they will receive for surgery.
7.3	Identify potential sources of this information (e.g., participants themselves, health records, databases, third parties).	Health records and participants themselves.
7.4	How will the personal health information be used in the research?	Patient age, BMI, smoking status, sex, education, living arrangement, geographic location, marital status and ASA grade will all be used to see if any of these factors are predictive in determining a reason why a patient may still be in hospital.
7.5	Explain why the research could not reasonably be accomplished without using the personal health information.	Without this information, we cannot tailor care offered on 7.3 to these patients. This information will allow healthcare staff to target care based on the patients demographic characteristics.
7.6	Will personal health information maintained by the institution(s) be combined with personal information from other sources to form a composite record (data linkage)?	No
7.7	If yes, describe the other personal information and its source(s) and how the linkage will be conducted.	
7.8	Will the personal health information be used in the most de-identified form possible for the conduct of the research?	Yes
7.9	Please comment, and explain how any de-identification will be performed.	Patient identification numbers will be assigned to each patient, where only the patient ID will be used when collecting data or when analyzing it.
7.10	Describe reasonably foreseeable risks arising from the use of the personal health information and how these risks will be mitigated. (Privacy Breach)	Only the Principal Investigator, Supervising investigator, Research Coordinator(s) will have access to the personal health information. All others responsible for reviewing and analyzing the data will only have access to de-identified data.
7.11	If applicable, describe any other safeguards and risk mitigation measures to protect personal health information from unauthorized collection, use and disclosure.	De-identified data will be maintained in a password-protected database on a password-protected Nova Scotia Health Authority (NSHA) computer in a locked office. Study documents are kept securely with the research locked office. The research office is locked at all times and only research team members have access to this office. The research office is located in the Abbie J. Lane Building, room 3068. All study personnel are bound by NSHA privacy and confidentiality policies.

7.12	Will personal health information (PHI) be accessed for study purposes?	Yes
7.13	If PHI will be accessed for study purposes, who will have access to the PHI? Tick all that apply.	Principal Investigator |Supervising Investigator |Research coordinator(s)
7.14	List any additional study roles (not mentioned in the previous list) that will be accessing PHI for study purposes.	
7.15	For each individual role (e.g. PI, Sponsor, coordinator, etc.) that will have access to the PHI, explain why their access is necessary, and list their qualifications (see description for definition).	PI: Ryan Greene is a PhD student in the Faculty of Medicine (Clinical Epidemiology) at Memorial University of Newfoundland and a research coordinator in the Division of Neurosurgery at Nova Scotia Health. Ryan possesses his Master of Science in Medicine (Clinical Epidemiology) and will be collecting data for reasons why a patient isn't discharged, and will also be building the database used for the analysis. Ryan will also be performing all statistical analysis for the study. Supervising Investigator: Dr. Sean Christie is a spine neurosurgeon at the Halifax Infirmary. Dr. Christie is also a co-supervisor for Ryan Greene for his PhD studies.
7.16	Describe administrative, physical and technical measures to be taken to safeguard the personal health information and study data.	The research is locked at all times and only research team members involved in the study have access to the research office where the data will be stored. Each subject has their own study ID which will keep them de-identified in the database. All study documents are stored on a password protected computer, which only research staff involved have access. Computers are password protected and are kept behind the NSHA firewall.
7.17	Where and how will personal health information and study data be stored during the course of the study (while it is active)?	All data will be stored on password protected computers in the research office, which is locked and only members of the research team will have access to.The research office is located in the Abbie J. Lane Building, room 3068. Furthermore, all participants will be de-identified with their own study ID number in the database.
7.18	Will participant information be transferred to parties outside the Nova Scotia Health Authority (e.g., identifying or de-identified study data, lab requisitions/results, EKG or X-ray reports, discharge summaries, survey results)?	No
7.19	If yes, which information will be transferred? To whom, to where, and how will the information be transferred?	

7.20	If yes, explain how information will be de-identified or (in the case of identifying information) how participant permission will be obtained.	
7.21	Is the transfer covered in the research agreement or in a data transfer agreement?	Not applicable
7.22	Will researchers' personal information be transferred to parties who may store or access the information outside Canada?	No
7.23	If yes, how will the individuals' consent be obtained and recorded?	
7.24	If yes, describe any measures taken to minimize and protect the personal information (e.g. abbreviated CVs).	
7.25	Where and how will research records be stored after study closure?	Research records will be transferred to Research Services, Central Zone, NSHA for long term storage per our institutional policy.
7.26	How long will these records be stored?	7 years
7.27	How and by whom will the records be securely destroyed, permanently erased (ie IT) and/or de-identified at the end of the retention period?	Research Services will arrange for the destruction in accordance with the applicable standards.
7.28	Will interviews or focus groups be conducted?	Yes
7.29	If yes, will sessions be recorded?	No
7.30	If yes, will participants be asked to review transcriptions for accuracy?	No
7.31	Will survey software be used?	No
7.32	If survey software will be used, which vendor(s) will be used and where will the servers be located? (Must be in Canada)	
7.33	Will there be data matching?	No
7.34	If yes, explain why data matching is required.	

8. Other Ethical Issues

#	Question	Answer
8.1	Are you aware of any other ethical issues regarding the design or conduct of the study (i.e. blinding)?	No
8.2	If yes, describe the issues and explain how they will be addressed.	

Attachments

Doc / Agreement	Version Date	File Name	Description
Approval Letter - REB Use Only	2021/03/04	DR1026525final.docx	N/A
Certificate of Completion TCPS 2: CORE	2023/06/01	tcps2_core_certificate.pdf	RDG TCPS2: June 1 2023
Consent Form - paper version	2021/03/02	consent-non-interventional-studies-March 2 2021 Version 1.3.doc	Informed Consent form Version 1.3- March 2, 2021
Renewal - REB Use Only	2024/02/26		March 4, 2024 - March 4, 2025
Research Protocol	2021/01/15	Barriers to Discharge Protocol January 15 2021.docx	Research Protocol Version 1.0
Supporting Materials	2020/11/03	Barriers to Discharge List November 3 2020.docx	Data Collection Sheet
Supporting Materials	2021/01/15	Pre-Operative Data Collection.docx	Pre-Operative Data Collection Form
Certificate of Completion TCPS 2: CORE	2012/02/17	Dr.Christie TCPS2 Feb 17 2012.pdf	SI TCPS2
Certificate of Completion TCPS 2: CORE	2017/04/12	tcps2_core_certificate Ryan Greene.pdf	TCPS2 PI
Consent Form - paper version	2021/01/13	consent-non-interventional-studies-Jan 13 2021.doc	Non-Interventional

			Study Informed Consent
Consent Form - paper version	2021/02/23	consent-non-interventional-studies-February 23 2021 Version 1.1.docx	Informed consent Form Version 1.1-February 23, 2021
Curriculum Vitae (CV)	2020/11/20	CCV-SeanChristie-CIHR_Biosketch (5-pages-spine).pdf	SI CV
Curriculum Vitae (CV)		Ryan D Greene CV.docx	PI CV
Curriculum Vitae (CV)	2021/02/23	Ryan D Greene CV Signed.pdf	PI Ryan Greene CV Signed-February 23, 2021
Initial Letter - REB Use Only	2021/02/02	DR1026525IL.docx	N/A
Investigator Response/Revisions	2021/02/24	Cover Letter-Barriers To Discharge Study 1026525.docx	Cover Letter-February 24, 2021
Investigator Response/Revisions	2021/03/02	Cover Letter-Barriers To Discharge Study 1026525 March 2 2021.docx	Cover Letter-March 2, 2021
Letter of Support	2021/01/07	2021 01 07 SI and PI Letter of Support.pdf	PI and SI letters of Support
Renewal - REB Use Only	2022/03/28		Mar 04, 2022-Mar 04, 2023
Renewal - REB Use Only	2023/02/10		Mar 4, 2023-Mar 4, 2024
Researcher's Checklist for Submission	2021/01/15	researchers-checklist-submissions-non-	Researcher Checklist

		interventional-2021 01 15.doc	
Researcher's Commitment Form	2020/12/16	researchers-commitments-supervising-investigator-2020-04-30.pdf	SI Commitments
SOP	2018/11/29	SOP 15 (a) signed.pdf	SOP 15 Obtaining Consent
SOP	2018/11/29	SOP 14 signed.pdf	SOP 14 Screening

Appendix 4.2: Protocol uploaded to open science framework for the barriers to discharge study.

What Barriers Prevent Patient's from being Discharged from Hospital Following Elective Spine Surgery: A Prospective Cohort Study

Ryan Greene[1, 2], Amanda Hall[1], Holly Etchegary[1] and Sean Christie[2]

1. Faculty of Medicine, Memorial University of Newfoundland, St. John's, NL

2. Department of Surgery (Neurosurgery), Dalhousie University, Halifax, NS

Corresponding Author: Ryan Greene, rdg068@mun.ca

Keywords: Spine surgery, length of stay, barriers to discharge, quality improvement, audit

Background:

Enhanced Recovery After Surgery (ERAS) interventions are pathways designed to improve patients' recovery after surgery. Evidence from randomized controlled trials (RCTs) of ERAS interventions in fields such as colorectal surgery, pelvic, hip/knee, and gynecologic/oncology surgery have shown improvements on length of stay (LoS), patient satisfaction, and costs to the healthcare system (Parisi et al., 2020; Zhang et al., 2020). However, less is known about ERAS interventions for spinal surgery. Currently, the Spine Program at the QEII Hospital in Nova Scotia, Canada has been developing an ERAS intervention as part of a quality improvement (QI) initiative for scheduled spine surgery.

One of our first QI aims was to gain a better understanding of the reasons that patients are staying in hospital after surgery. This will allow us to select strategies that will better facilitate patients' safe discharge at our site. A secondary aim is to understand why the patients think they are still in hospital. Anecdotally, we have heard that patients often think they are still in hospital to have their pain managed and will not be discharged until they are pain free when in actual fact being pain free is not one of the criteria for discharge. Thus, we thought gaining a better understanding of patients' perceptions of recovery and discharge from hospital might provide us with valuable information that would help us develop better patient education resources.

Study Objectives:

1. To identify the hospital-based reasons patients are not discharged after a one-night hospital stay (e.g. stayed in hospital for more than one night) of their scheduled spine surgery at the QEII.
2. To understand why patients think they are still in hospital and to see if there is a knowledge gap between the reasons patients think they are still in hospital compared to the hospital's reasons for continued stay.

Methods:

Research Study Design: This will be a prospective cohort study, including all patients who receive elective spine surgery for a degenerative condition, within a 6-month period.

This protocol has been developed according to the Standards for reporting for observational studies (STROBE) guidelines. A copy of the completed STROBE Checklist can be found in Appendix 1.

Ethics: Ethics has been obtained by the Nova Scotia Health Research Ethics Board, file number 1026525.

Setting: A single hospital center, the QEII in Nova Scotia is the setting for this study. This site offers surgeries for a broad range of conditions during Monday-Friday from 8:00am-5:00pm. After surgery and recovery from anesthesia, patients are moved to the dedicated inpatient spine floor which has one charge nurse and multiple registered nurses. Generally, once a patient is able to ambulate independently, fully empty their bladder, have a bowel movement, have pain management which does not require hospitalization, they are discharged either to home, or to further facilities if necessary.

Participants: all patients who meet the inclusion criteria below will be included.

Inclusion Criteria:

- Patients 18 and older.

- Patients undergoing scheduled posterior cervical or degenerative lumbar fusion procedures. For example, diseases included for elective surgery are lumbar stenosis, lumbar disc herniation, lumbar spondylolisthesis and cervical myelopathy.

Exclusion Criteria:

- Any spine procedure which is considered urgent/emergent.
- Day-stay/Same day discharge procedures.
- Infection or cancer related procedures.
- Lumbar fusion for deformity (such as scoliosis).

Recruitment: Every day at 8:00am, the operating room schedule for the spine surgeons will be screened for surgical candidates meeting our inclusion criteria. All patients who meet the inclusion criteria above will be automatically included in the study and given a participant ID code. Patients who are identified to have a hospital stay of longer than one night, are deemed to have a factor which prolongs their hospital stay. These patients with a prolonged stay would then have the charge nurse provide the reason(s) why that patient remains in hospital. The patient would also be approached to ask them what they thought contributed to them having a prolonged stay as well.

Data collection procedures: For all included participants, the researcher (RG) will meet with and interview the charge nurse at 10:00am the day following the patient's surgery. The first question will pertain to length of stay, to determine if the patient would be going home that day, or if they have a barrier preventing them from discharge, meaning they would stay in hospital for a second night. For those participants who have a medical, technical, or logistic factor preventing discharge that day, they will continue to be included in the hospital reasons for prolonged stay part of the study. This will involve data being collected by the researcher from the charge nurse about the patient at 10am and 3pm every day until they were discharged. All participants in this part of the study will be approached by the researcher (RG) and asked if they would be interested in taking part in the "patient reasons for prolonged stay" study. Patients will be provided with informed consent, and if they agree to the study, will also be interviewed to find out what the patient believes is keeping them in hospital. Note: Patients who refused consent would still be enrolled in the audit of the hospital's reason for prolonged stay but not enrolled in the assessment of the patient's perception of their reasons for remaining in hospital.

Data collection variables: Baseline patient characteristics were collected for all participants. Length of stay and hospital reasons for prolonged stay were collected for all participants to answer objective 1. Patient's reason for prolonged stay along with additional demographic characteristics were collected for consenting participants to

answer objective 2. The outcomes are described in more detail below. A copy of the data collection sheet used by the researcher is in Appendix 3.

- *Baseline*: For all included patients, the following baseline characteristics were recorded from the patient's chart: Patient's age, sex, BMI, and ASA grade and discharge destination recorded (home, home hospital or rehab center), specialty of the surgeon (neurosurgery or orthopaedic surgery), surgical site (lumbar or cervical), and surgical procedure performed (decompression alone or a decompression and fusion) (See Appendix 2).
- *Length of stay:* Length of stay data was recorded from the charge nurse. Length of stay is defined in days and is measured as the number of nights a patient stays in hospital until discharge.
- *Reasons for prolonged stay/preventing discharge*: Patients who were not discharged after a one-night stay following their surgery, are classified as having a prolonged stay and included for data collection on reasons for prolonged stay in hospital or not being discharged. The data were collected using a standardised data extraction form (see Appendix 3). A list of potential reasons for prolonged stay was presented to the nurse, these included: poor pain management, dizziness, confusion, sedation, post-op nausea and/or vomiting, urinary retention, muscle weakness, technical reasons and logistic reasons. An option to select "other" will also be provided, with space for a description being available.

Patients who consented to be interviewed for the study will also have the following outcomes collected:

- *Additional patient variables:* smoking status, height, weight, education level, marital status, living arrangement and the first three alphanumeric digits of their postal code
- *Patient-reported reason for remaining in hospital/non-discharge*: The exact same list of potential reasons for prolonged stay which was presented to the nurse will be provided to the patient as well.

Sample size: This study will examine all patients who meet our inclusion criteria for the 6-month period that data collection is ongoing. It is anticipated approximately 200 people will be recruited.

Analysis:

Baseline data: Continuous variables are to be described with means and standard deviations, with categorical variables being described with frequency and percentages.

Length of stay: Length of stay will be reported as a mean and standard deviation. The median for LoS will also be reported.

Hospital and patient reported reasons for prolonged stay: Every reason provided will form one reason category. The frequency of reporting (and relative percentage of all reasons reported) each reason as a reason for preventing discharge will be reported at each time period collected. Differences between hospital and patients factors keeping patients in hospital will be compared descriptively.

All data will be analyzed using SPSS Version 28 (IBM, Armonk, NY, USA). Examples of results tables are below.

Table 1: Patient baseline characteristics

Patient characteristics	Total sample (n=)	Sample discharged same day (n=)	Sample with prolonged stay (n=)
Age (mean, SD)			
Sex (%female)			
BMI			
ASA grade			
Discharge destination			
Surgical site			
• cervical			
• lumbar			
Surgery Type			
• Decompression Alone			
• Decompression and Fusion			

Reasons for prolonged stay: A description of the reasons for prolonged stay at 10am and 3pm of each day until discharge.

Table 2: Hospital-reported primary reasons for prolonged stay

	Day 1 10am	Day 1 3pm	Day 2 10am	Day 2 3pm	Day 3 10am	Day 3 3pm	Day 4 10am	Day 4 3pm	Day 5 10am	Day 5 3pm	….
% of those with prolonged stay not discharged (n=)	100%										
Reasons for prolonged stay											
poor pain management											
dizziness											
confusion											
sedation											
post-op nausea and/or vomiting											
urinary retention											
muscle weakness											
technical reasons											
Mobilization											
logistic reasons											
Other reasons provided:											
• add other reason 1											
• add other reason 2											
• add other reason 3											

• add other reason 4											
**The charge nurse is asked: include exact question here											

***Patient reasons for remaining in hospital/non-discharge**:*

Table 3: Patient-reported reasons for prolonged stay

	Day 1 10am	Day 1 3pm	Day 2 10am	Day 2 3pm	Day 3 10am	Day 3 3pm	Day 4 10am	Day 4 3pm	Day 5 10am	Day 5 3pm	….
% of those with prolonged stay not discharged (n=)	100%										
Reasons for prolonged stay											
poor pain management											
dizziness											
confusion											
sedation											
post-op nausea and/or vomiting											
urinary retention											
muscle weakness											
technical reasons											
Mobilization											
logistic reasons											
Other reasons provided:											
• add other reason 1											
• add other reason 2											
• add other reason 3											
• add other reason 4											
**The patient is asked: include exact question here											

References:

Parisi A, Desiderio J, Cirocchi R, Trastulli S. Enhanced Recovery after Surgery (ERAS): a Systematic Review of Randomised Controlled Trials (RCTs) in Bariatric Surgery. Obes Surg. 2020;30(12):5071-5085. doi:10.1007/s11695-020-05000-6

Zhang D, Sun K, Wang T, et al. Systematic Review and Meta-Analysis of the Efficacy and Safety of Enhanced Recovery After Surgery vs. Conventional Recovery After Surgery on Perioperative Outcomes of Radical Cystectomy. Front Oncol. 2020;10:541390. doi:10.3389/fonc.2020.541390

Appendix 1: STROBE checklist of items included in the study.

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	

		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up (*b*) For matched studies, give matching criteria and number of exposed and unexposed	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4/5
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed	5

		(e) Describe any sensitivity analyses	
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	

Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			

Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

*Give information separately for exposed and unexposed groups.

Appendix 2: Pre-operative data collection for patient baseline demographics and anthropometrics.

Barriers to Discharge Study **PID: _____ Date: _____**

Pre-Operative Information: **Surgeon: _____**

Age: _____ Sex: _____ Height: _____ Weight: _____

Smoking Status: ☐Smoker ☐Non-Smoker

Education Level:

☐Less than high school

☐High school diploma

☐Technical school or Associate degree

☐College/University degree/Undergraduate degree

☐Post Graduate or professional degree

☐Choose not to answer

Living Arrangement:

☐Living Alone

☐Living with a Partner/Roommate/Family

☐Living in Retirement/Nursing Home

☐Choose not to answer

Marital Status:

☐Single

☐Married/Engaged/Common law

☐**Divorced/Separated**

☐**Widowed**

☐**Choose not to answer**

Geographic Location (First three alphanumeric digits of postal code): _____ASA Grade: _____

Appendix 3: List of factors which may prevent a patient from being discharged from hospital following elective spine surgery.

Barriers to Discharge **PID:_____**

Date:_____

Please provide a primary and secondary barrier to discharge with a 1 and a 2 respectively.

Date:	**10am**	**3pm**
Pain Management		
Dizziness		
Confusion		
Sedation		
Post-op Nausea/vomiting		
Urinary retention		
Muscle Weakness		
Technical reasons		
Logistic reasons		

Other:

Date of Surgery: _____

Length of Stay to date: _____

Surgeon:_____

Appendix 4.3: STROBE checklist for the barriers to discharge study.

	Item No	Recommendation	Page No
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	1
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	2
Objectives	3	State specific objectives, including any prespecified hypotheses	2
Methods			
Study design	4	Present key elements of study design early in the paper	3
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	3
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	4
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	4
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	4/5
Bias	9	Describe any efforts to address potential sources of bias	5
Study size	10	Explain how the study size was arrived at	5
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	5
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	

		(*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) If applicable, explain how loss to follow-up was addressed (e) Describe any sensitivity analyses	5
Results			
Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram	6
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) Summarise follow-up time (eg, average and total amount)	
Outcome data	15*	Report numbers of outcome events or summary measures over time	
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (*b*) Report category boundaries when continuous variables were categorized (*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	
Discussion			
Key results	18	Summarise key results with reference to study objectives	

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	
Generalisability	21	Discuss the generalisability (external validity) of the study results	
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	

Appendix 4.4: Pre-Operative patient questionnaire for the barriers to discharge study.

Barriers to Discharge Study **PID: _____ Date: _____**

Pre-Operative Information: **Surgeon: _____**

Age: _____ Sex: _____ Height: _____ Weight: _____

Smoking Status: ☐Smoker ☐Non-Smoker

Education Level:

☐Less than high school

☐High school diploma

☐Technical school or Associate degree

☐College/University degree/Undergraduate degree

☐Post Graduate or professional degree

☐Choose not to answer

Living Arrangement:

☐Living Alone

☐Living with a Partner/Roommate/Family

☐Living in Retirement/Nursing Home

☐**Choose not to answer**

Marital Status:

☐**Single**

☐**Married/Engaged/Common law**

☐**Divorced/Separated**

☐**Widowed**

☐**Choose not to answer**

Geographic Location (First three alphanumeric digits of postal code): _____

ASA Grade: _____

Appendix 4.5: Reasons for potential barriers to discharge provided to both the charge nurse and patients alike.

Barriers to Discharge **PID:_____**

Date:_____

Please provide a primary and secondary barrier to discharge with a 1 and a 2 respectively.

Date:	**10am**	**3pm**
Pain Management		
Dizziness		
Confusion		
Sedation		
Post-op Nausea/vomiting		
Urinary retention		
Muscle Weakness		
Technical reasons		
Mobilization		
Logistic reasons		

Other:

Date of Surgery: _____

Length of Stay to date: _____

Surgeon:_____

Appendix 4.6: Demographic and clinical characteristics of patients who were discharged after a 1-night stay, and those who had an inpatient stay of >1-day. A 1-way ANOVA was performed for continuous data, with chi-square tests of proportion being used for categorical tests.

Patient Characteristics	Sample discharged same day (n=55)	Sample with prolonged stay (n=47)	P-Value
Age (mean, SD)	59.07±11.36	62.57±12.20	0.137
Sex (%female)	26 (47.30%)	23 (48.9%)	0.867
BMI	30.41±5.70	30.09±7.29	0.806
ASA Grade 1	2 (1.96%)	2 (1.96%)	0.842
ASA Grade 2	37 (36.27%)	29 (28.43%)	
ASA Grade 3	16 (15.69%)	16 (15.69%)	
Discharge destination			
Home	55 (100.00%)	36 (76.60%)	<0.001
Home Hospital	0 (0.00%)	6 (12.77%)	
Rehab Center	0 (0.00%)	5 (10.63%)	
Surgical site			
cervical	31 (56.36%)	17 (36.17%)	0.052
lumbar	24 (43.64%)	30 (63.83%)	
Surgery Type			
Decompression Alone	21 (38.18%)	22 (46.81%)	0.379
Decompression and Fusion	34 (61.82%)	25 (53.19%)	
LoS	1±0	4.66±4.49	<0.001

Appendix 5.1: GRIPP2 Short form checklist for the patient educational content and delivery study.

Section and topic	**Item**	**Reported on page No**
1: Aim	Report the aim of PPI in the study	96

Section and topic	Item	Reported on page No
2: Methods	Provide a clear description of the methods used for PPI in the study	97-101
3: Study results	Outcomes—Report the results of PPI in the study, including both positive and negative outcomes	101-105
4: Discussion and conclusions	Outcomes—Comment on the extent to which PPI influenced the study overall. Describe positive and negative effects	106-111
5: Reflections/critical perspective	Comment critically on the study, reflecting on the things that went well and those that did not, so others can learn from this experience	N/A

Appendix 5.2: SRQR checklist for the patient educational content and delivery study.

Standards for Reporting Qualitative Research (SRQR)*

http://www.equator-network.org/reporting-guidelines/srqr/

	Page/line no(s).
Title and abstract	
Title - Concise description of the nature and topic of the study Identifying the study as qualitative or indicating the approach (e.g., ethnography, grounded theory) or data collection methods (e.g., interview, focus group) is recommended	94
Abstract - Summary of key elements of the study using the abstract format of the intended publication; typically includes background, purpose, methods, results, and conclusions	N/A
Introduction	
Problem formulation - Description and significance of the problem/phenomenon studied; review of relevant theory and empirical work; problem statement	95-96

Purpose or research question - Purpose of the study and specific objectives or questions	96

Methods

Qualitative approach and research paradigm - Qualitative approach (e.g., ethnography, grounded theory, case study, phenomenology, narrative research) and guiding theory if appropriate; identifying the research paradigm (e.g., postpositivist, constructivist/ interpretivist) is also recommended; rationale**	97
Researcher characteristics and reflexivity - Researchers' characteristics that may influence the research, including personal attributes, qualifications/experience, relationship with participants, assumptions, and/or presuppositions; potential or actual interaction between researchers' characteristics and the research questions, approach, methods, results, and/or transferability	N/A
Context - Setting/site and salient contextual factors; rationale**	97-98
Sampling strategy - How and why research participants, documents, or events were selected; criteria for deciding when no further sampling was necessary (e.g., sampling saturation); rationale**	99-101
Ethical issues pertaining to human subjects - Documentation of approval by an appropriate ethics review board and participant consent, or explanation for lack thereof; other confidentiality and data security issues	N/A
Data collection methods - Types of data collected; details of data collection procedures including (as appropriate) start and stop dates of data collection and analysis, iterative process, triangulation of sources/methods, and modification of procedures in response to evolving study findings; rationale**	99-101
Data collection instruments and technologies - Description of instruments (e.g., interview guides, questionnaires) and devices (e.g., audio recorders) used for data collection; if/how the instrument(s) changed over the course of the study	99-101
Units of study - Number and relevant characteristics of participants, documents, or events included in the study; level of participation (could be reported in results)	101
Data processing - Methods for processing data prior to and during analysis, including transcription, data entry, data management and security, verification of data integrity, data coding, and anonymization/de-identification of excerpts	99
Data analysis - Process by which inferences, themes, etc., were identified and developed, including the researchers involved in data analysis; usually references a specific paradigm or approach; rationale**	101

Techniques to enhance trustworthiness - Techniques to enhance trustworthiness and credibility of data analysis (e.g., member checking, audit trail, triangulation); rationale**	N/A

Results/findings

Synthesis and interpretation - Main findings (e.g., interpretations, inferences, and themes); might include development of a theory or model, or integration with prior research or theory	101-102
Links to empirical data - Evidence (e.g., quotes, field notes, text excerpts, photographs) to substantiate analytic findings	102-105

Discussion

Integration with prior work, implications, transferability, and contribution(s) to the field - Short summary of main findings; explanation of how findings and conclusions connect to, support, elaborate on, or challenge conclusions of earlier scholarship; discussion of scope of application/generalizability; identification of unique contribution(s) to scholarship in a discipline or field	106-110
Limitations - Trustworthiness and limitations of findings	110-111

Other

Conflicts of interest - Potential sources of influence or perceived influence on study conduct and conclusions; how these were managed	N/A
Funding - Sources of funding and other support; role of funders in data collection, interpretation, and reporting	N/A

*The authors created the SRQR by searching the literature to identify guidelines, reporting standards, and critical appraisal criteria for qualitative research; reviewing the reference lists of retrieved sources; and contacting experts to gain feedback. The SRQR aims to improve the transparency of all aspects of qualitative research by providing clear standards for reporting qualitative research.

**The rationale should briefly discuss the justification for choosing that theory, approach, method, or technique rather than other options available, the assumptions and limitations implicit in those choices, and how those choices influence study conclusions and transferability. As appropriate, the rationale for several items might be discussed together.

Reference:
O'Brien BC, Harris IB, Beckman TJ, Reed DA, Cook DA. **Standards for reporting qualitative research: a synthesis of recommendations.** *Academic Medicine*, Vol. 89, No. 9 / Sept 2014
DOI: 10.1097/ACM.0000000000000388

Appendix 5.3: Letter sent to patient partners via email to facilitate interest in the discussion group.

Development of an Enhanced Recovery After Surgery (ERAS) Protocol for Major Spine Surgery at the Halifax Infirmary: How do we Improve Pre-Operative Patient Education?

My name is Ryan Greene, and I am a Doctoral student in the Division of Community Health and Humanities at Memorial University of Newfoundland. My project aims to introduce the first enhanced recovery after surgery program for spine surgery in Canada while working with the Division of Neurosurgery in Halifax, Nova Scotia. A critical component for implementing this program is to identify ways to improve patient education pre-operatively. Through this, we hope to have patients better prepared for their surgery, and hope to have them more engaged to help facilitate a speedy and healthy recovery.

Enhanced Recovery After Surgery (ERAS) protocols are well-established pathways designed to improve patient's recovery after surgery. ERAS was first introduced in Denmark in the early 1990's by Henrik Kehlet, designing a fast-track approach to abdominal surgery. Currently, ERAS is well defined in many surgical fields, such as colorectal surgery, pelvic, hip/knee, and gynecologic/oncology surgery. Frequently reported metrics for determining the success of an ERAS program typically focus on length of stay (LoS), patient satisfaction, and costs to the healthcare system.

Patient education is a pivotal component in ERAS. Currently, at the Halifax Infirmary, patients receive a pamphlet with information regarding what they need to prepare for surgery, and what to look out for during their recovery process. A spine surgeon will also go over the procedure with the patient when surgery is offered. Due to the invasiveness and complexity of spine surgery, length of stay in hospital varies greatly patient to patient. Furthermore, there is significant involvement required of the patient in mitigating pain, and in expediting their recovery. For example, post-operative mobility and nutrition are encouraged to help the patient recover efficiently.

By working with patients now, we want to know:

1. How can we deliver information to the patient in a way that helps them retain knowledge about the procedure and what expectations are placed on them? Examples include:
    a. Should we deliver online or in person classroom sessions for patients prior to surgery with a Nurse Practitioner?

b. Would an audio/video booklet with videos catered to each phase of care be beneficial?
c. Would an open phone line with a nurse during select hours be utilized by patients?
d. How do we involve family members/caretakers of the patient so they can aid in the patient's recovery?
e. What other methods not mentioned could be effective in disseminating education?

Thank you for your time in reading this and if you would be interested in taking part in this project, please contact myself at rdg068@mun.ca or my supervisor, Dr. Holly Etchegary at holly.etchegary@med.mun.ca.

Sincerely,

Ryan

Appendix 5.4: PowerPoint presentation provided to attendees.

Project Scope and Enhanced Recovery After Surgery

Enhanced recovery after surgery (ERAS) is a process aimed at improving patient care pre-, intra- and post-operatively.

Each phase focuses on factors both patients and healthcare professionals can do to be more efficient in providing care.

Well established in other surgical fields.

Spine surgery is challenging due to how invasive it can be and how long the recovery process is.

Goal

- Improve patient education delivery methods for patients scheduled for elective spine surgery.

  Common diseases include: Stenosis, myelopathy, disc herniations and spondylolisthesis.

Patient education needs to be delivered in a way that is accessible to those comfortable and not comfortable with technology. Is access to technology an issue to begin with?

Current Education Offered

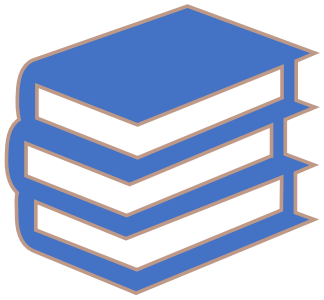
Patients are offered surgery and provided details about the surgery when the surgeon offers them informed consent.

A booklet is then provided to each patient based on whether they are receiving surgery on their back or neck.

This booklet is 26 pages long.

What's in the Booklet

- The booklet includes information on:
  - What your disease is.
  - How the procedure works.
  - What you need to prepare for surgery.
  - What to expect during your recovery.
  - What to bring with you for your hospital stay.



Possible Education Alternatives

- In person classroom sessions with our nurse practitioner.
- "Office-hours" where a Registered nurse can be called during the week if the patient has any questions in the lead up to surgery.
- YouTube videos catered to each type of surgery or pathology a patient may experience.
- An audio-video booklet.
  - Booklet has a screen on the inside, with videos that describe what to expect pre-, intra-, and post-operatively.
  - Also includes text with important information summarized about your procedure.

Possible Education Alternatives

- In person classroom sessions with our nurse practitioner.
- "Office-hours" where a Registered nurse can be called during the week if the patient has any questions in the lead up to surgery.
- YouTube videos catered to each type of surgery or pathology a patient may experience.
- An audio-video booklet.
  - Booklet has a screen on the inside, with videos that describe what to expect pre-, intra-, and post-operatively.
  - Also includes text with important information summarized about your procedure.

Appendix 6.1: Protocol published on Open Science Framework for the content and delivery of patient education in spine ERAS systematic review.

Content of Enhanced Recovery After Surgery Patient Educational Material in the Spine Surgery Setting: A Review of the Literature and Canada Wide Educational Materials

Ryan Greene, Holly Etchegary, Sean D. Christie, and Amanda Hall

Introduction:

Enhanced recovery after surgery (ERAS) protocols are common in many surgical settings and are effective at reducing length of stay[1]. In recent years, spinal surgery has also begun to adopt ERAS protocols more frequently[2]. A common hallmark of these protocols is the use of patient education pre-operatively[1]. While education alone has not been shown to reduce length of stay, patient education is an important component of the surgical journey for the patient, as it can help manage expectations for the patient and their recovery[2]. Research has shown that outcome uncertainty is associated with increased patient anxiety and fear, which can negatively impact recovery[3]. For example, patients with improved pre-operative education tend to have better post-operative mobility, as well as reduced pain and anxiety scores[3]. In recent years, patient education is shifting to try to facilitate the patient to become an active participant in their own care, alongside their healthcare team[4]. Furthermore, education is beneficial not just for the patient, but should also be provided to the patient's caregiver as well[5].

While patient education is an important component of the surgical pathway, ERAS protocols vary widely in their delivery of educational material, as well as what content is provided during knowledge dissemination. This systematic review sought to determine how education was delivered to patients in ERAS pathways who undergo elective spine surgery for a degenerative disease and what content is included in education materials. This work could help inform the design of future educational material, in regard to what content is included, and how education is delivered.

Methods:

To conduct a content analysis of all patient education materials used as part of ERAS spine interventions, we will include two different types of education materials (i) those that have been evaluated in the literature and (ii) those that have haven't been evaluated but are being used as part of Canadian spinal surgery departments that are implementing ERAS. We have included the second information source because our pilot test of obtaining the actual education materials from ERAS interventions in the literature proved limited, which would in turn limit our ability to assess content and subsequently develop a thorough logic model for patient education used within ERAS interventions.

We will use a systematic review design following PRISMA guidelines to answer our question. Below we outline our review methods to identify all eligible materials and conduct data collection and synthesis.

Eligibility Criteria: Education materials will be included if they meet the following criteria:

Target audience: were developed to provide information for adult patients (aged 18 and older), who are going to receive surgery for a degenerative condition of the spine.

Target setting: delivered as part of a fully developed ERAS pathway, utilizing ERAS during the pre-, peri-, and post-operative phases of the patient's surgical journey.

Evaluation setting: have been either evaluated within a study or are being used as part of an ERAS pathway in a Canadian spinal surgery department.

Information Sources:

We will use two methods to identify patient education materials for spinal surgery

(i) Primary source - Systematic Search of the Literature:

A prior systematic review and meta-analysis was performed, that identified studies which used ERAS protocols in spine surgery[6] which searched PubMed, CINAHL, and Embase. A search string was developed with a health sciences librarian, and included terms related to spine surgery and ERAS. The search string can be found in Appendix 1.

(ii) Secondary source - Spine Surgery departments across Canada implementing ERAS:

We will use the Canadian Spine Outcomes Research Network (CSORN), who house a national registry of spinal surgery departments that volunteer to participate in a national research database[7]. This includes 18 centers which represent about half of all spine departments in Canada. We will check the websites of all CSORN departments to identify which ones are using ERAS. The list will be reviewed by content experts (SDC, RG) to identify additional departments who are using ERAS but do not have the information listed on their website or are not part of CSORN.

Selection Process:

As per the previous systematic review, one author extracted data from included studies with a second author checking the data for errors[6]. All papers were screened for inclusion by two reviewers. In the event there was a disagreement on inclusion for a paper, a third reviewer would decide whether the paper was included or not. For the web search, one author (RG) extracted all data from Google once patient educational material was identified.

CSORN – All CSORN sites were searched on Google for their local health authority, university and hospital setting for educational material related to spine surgery. A content expert (SDC), then also provided additional information identifying which sites actively use an ERAS spine program in Canada.

Data extraction:

One author (SDC) will ensure that each Canadian site that provides an ERAS program will be identified and contacted, requesting the educational material from that center. If other centers do not provide their ERAS educational material, a supplemental search will be pursued looking for educational material online. One author (RG) will abstract all data.

Study characteristics:

For each identified study in the systematic review, the study must state if patient education was used as a part of the ERAS program. If education is used as a component of ERAS, how the education was implemented will be abstracted, as well as education content, such as information on the surgery itself, managing patient expectations, or on ERAS.

Intervention characteristics:

For the educational material from the systematic review, information about how the educational material is provided to patients, and what content is included in the education will be described. Only studies which include education for their ERAS program will be included. In the event the educational material is attached as supplemental information in the paper, or is publicly available, the intervention will be described using the template for intervention description and replication (TIDieR) framework. If not available, the intervention will be described as it was in the paper itself.

For the CSORN sites, the intervention information will be abstracted from department, hospital, health authority or university websites that detail ERAS and patient education. In the event the patient education (such as booklets or videos) is provided on the website, the content will also be described using the TIDieR framework.

TIDieR

The TIDieR framework will be used to describe the education intervention for both the systematic search of the literature (Table 1), as well as for educational content across Canada (Table 2).

The TIDieR items that will be described are: A “brief name” and the “why” as to the reason this data will be abstracted, and why educational material is important for the ERAS intervention will be explained in an introductory sentence. Following this, the following data items will be captured in a table: “What”, which includes two columns, one describing what materials are used for the intervention, and then a procedures column, which will cover information on how the material is provided in the ERAS program. Who will be the next column and will describe the healthcare professional(s) who will administer the education. How will then explain what the mode of delivery of the content is, such as is the information verbal, in a classroom setting or in written materials. The where will also be covered, for the location that education is provided. Next, when, and how much will be described, detailing

how often the education is delivered, and when (pre-operatively, post-operatively). Tailoring and monitoring will be abstracted, detailing if the educational material can be modified or personalized for the patients' educational needs, and modifications will explain if the educational material was changed over the course of time.

Data Synthesis:

Information will be synthesized at two levels (i) content and (ii) delivery methods. The content is expected to include education which will cover the pre-, peri-, and post-operative phase of the patient's surgery, detailing information surrounding how to prepare for surgery, how the surgery is performed, and lastly, what to expect during the recovery.

References:

1. Ljungqvist, O. ERAS—Enhanced Recovery After Surgery. Journal of Parenteral and Enteral Nutrition. 2014. 38(5):559-566

2. Debono B, Wainwright TW, Wang MY, Sigmundsson FG, Yang MMH, Smid-Nanninga H, et al. Consensus statement for perioperative care in lumbar spinal fusion: Enhanced Recovery After Surgery (ERAS®) Society recommendations. The Spine Journal. 2021 May 1;21(5):729–52.

3. Burgess LC, Arundel J, Wainwright TW. The Effect of Preoperative Education on Psychological, Clinical and Economic Outcomes in Elective Spinal Surgery: A Systematic Review. Healthcare (Basel). 2019 Mar 21;7(1):48.

4. Graffigna G, Barello S. Patient Health Engagement (PHE) model in enhanced recovery after surgery (ERAS): monitoring patients' engagement and psychological resilience in minimally invasive thoracic surgery. J Thorac Dis. 2018 Mar;10(Suppl 4):S517–28.

5. Lee CH, Liu JT, Lin SC, Hsu TY, Lin CY, Lin LY. Effects of Educational Intervention on State Anxiety and Pain in People Undergoing Spinal Surgery: A Randomized Controlled Trial. Pain Manag Nurs. 2018 Apr;19(2):163–71.

6. Greene R, Hall A, Smith-Forrester J, et al. The Effect of Enhanced Recovery After Surgery Protocols for Elective Cervical and Lumbar Spine Procedures on Hospital Length of Stay: A Systematic Review and Meta-Analysis. Published online April 21, 2021. Accessed March 12, 2024. https://osf.io/3p6r5/

7. Participating Locations. CSORN. Accessed March 22, 2024. https://www.csorncss.ca/about/participating-locations/

Tables:

Table 1: TIDieR guidelines for describing the educational materials found from the systematic review.

Study/Year	What		Who	How	Where	When/How much?	Tailoring	Modifications	How Well? Was adherence assessed?	Content from study
	Materials	Procedures								

Table 2: TIDieR guidelines for describing the educational materials found from identifying ERAS programs in Canada via the content expert.

Province/Hospital/University	What		Who	How	Where	When/ How much?	Tailoring	Modifications	How Well? Was adherence assessed?
	Materials	Procedures							

Appendix 1: Search string used to conduct the systematic review.

PubMed:("Enhanced Recovery After Surgery"[Mesh] OR ERAS[tiab] OR "enhanced recovery"[tiab] OR (("Critical Pathways"[Mesh] OR "critical path"[tiab] OR "clinical pathway*"[tiab] OR "clinical path"[tiab] OR "clinical paths"[tiab] OR "multimodal pathway*"[tiab] OR pathway*[ti]) AND ("Postoperative Care"[Mesh] OR "Perioperative Care"[Mesh:NoExp] OR recovery[tiab] OR postoperative[tiab] OR "post operative"[tiab] OR perioperative[tiab] OR "perioperative"[tiab] OR surgical[tiab] OR surger*[tiab]))AND("Spine/surgery"[Mesh] OR "Back/surgery"[Mesh] OR "Spinal Diseases/surgery"[Mesh] OR "Spinal Fusion"[Mesh] OR "Vertebroplasty"[Mesh] OR "Diskectomy"[Mesh] OR "Laminectomy"[Mesh] OR "Laminoplasty"[Mesh] OR "Foraminotomy"[Mesh] OR ((spine[tiab] OR spinal[tiab] OR lumbar[tiab] OR stenosis[tiab] OR spondylolisthesis[tiab]) AND (surger*[tiab] OR surgical[tiab] OR fusion[tiab])) OR "spinal decompression"[tiab] OR discectomy[tiab] OR diskectomy[tiab] OR laminectomy[tiab] OR laminoplasty[tiab] OR laminotomy[tiab] OR foraminotomy[tiab] OR facetectomy[tiab] OR

spondylolisthesis[tiab] OR TLIF[tiab] OR PLIF[tiab] OR ALIF[tiab] OR LLIF[tiab] OR XLIF[tiab] OR OLIF[tiab] OR "anterior column realignment"[tiab]))NOT (Animals[Mesh] NOT Humans[Mesh])Embase (via embase.com): ('enhanced recovery after surgery'/de OR 'enhanced recovery':ab,ti OR eras:ab,ti OR 'clinical pathway'/de OR 'critical pathway*':ab,ti OR 'critical path':ab,ti OR 'critical paths':ab,ti OR 'clinical pathway*':ab,ti OR 'clinical path':ab,ti OR 'clinical paths':ab,ti OR 'multimodal pathway*':ab,ti OR pathway*:ti) AND ('postoperative period'/de OR 'perioperative period'/de ORrecovery:ab,ti OR postoperative:ab,ti OR 'post operative':ab,ti OR perioperative:ab,ti OR 'peri operative':ab,ti OR surgical:ab,ti OR surger*:ab,ti) AND ('spine surgery'/exp OR ((spine:ab,ti OR spinal:ab,ti OR lumbar:ab,ti OR stenosis:ab,ti OR spondylolisthesis:ab,ti) AND (surger*:ab,ti OR surgical:ab,ti OR fusion:ab,ti)) OR 'spinal decompression':ab,ti OR discectomy:ab,ti OR iscectomy:ab,ti OR laminectomy:ab,ti OR laminoplasty:ab,ti OR laminotomy:ab,ti OR foraminotomy:ab,ti OR facetectomy:ab,ti OR spondylolisthesis:ab,ti OR tlif:ab,ti OR plif:ab,ti OR alif:ab,ti OR llif:ab,ti OR xlif:ab,ti OR olif:ab,ti OR 'anterior column realignment':ab,ti)

NOT ('animal'/exp NOT 'human'/exp)CINAHL (via EBSCOhost): (MH "Enhanced Recovery After Surgery" OR TI "enhanced recovery" OR AB "enhanced recovery" OR TI ERAS OR AB ERAS OR ((MH "Critical Path" OR TI pathway* OR TI "critical path" OR TI "critical paths" OR TI "clinical path" OR TI "clinical paths" OR AB "critical pathway*" OR AB "critical path" OR AB "critical paths" OR AB "clinical pathway*" OR AB "clinical path" OR AB "clinical paths" OR AB "multimodal pathway*") AND (MH "Postoperative Care" OR MH "Postoperative Period" OR MH "Perioperative Care" OR TI recovery OR TI postoperative OR TI "post operative" OR TI perioperative OR TI "peri operative" OR TI surgical OR TI surger* OR AB recovery OR AB postoperative OR AB "post operative" OR AB perioperative OR AB "peri operative" OR AB surgical OR AB surger*)))AND(MH "Spine+/SU" OR MH "Back/SU" OR MH "Spinal Diseases+/SU" OR MH "Spinal Fusion" OR MH "Vertebroplasty+" OR MH "Diskectomy" OR MH "Laminectomy" OR MH "Laminoplasty" OR ((TI spine OR TI spinal OR TI lumbar OR TI stenosis OR TI spondylolisthesis) AND (TI surger* OR TI surgical OR TI fusion)) OR TI "spinal decompression" OR TI discectomy OR TI discectomy OR TI laminectomy OR TI laminoplasty OR TI laminotomy OR TI foraminotomy OR TI facetectomy OR TI spondylolisthesis OR TI TLIF OR TI PLIF OR TI ALIF OR TI LLIF OR TI XLIF OR TI OLIF OR TI "anterior column realignment" OR ((AB spine OR AB spinal OR AB lumbar OR AB stenosis OR AB spondylolisthesis) AND (AB surger* OR AB surgical OR AB fusion)) OR AB "spinal decompression" OR AB discectomy OR AB discectomy OR AB laminectomy OR AB laminoplasty OR AB laminotomy OR AB foraminotomy OR AB facetectomy OR AB spondylolisthesis OR AB TLIF OR AB PLIF OR AB ALIF OR AB LLIF OR AB XLIF OR AB OLIF OR AB "anterior column realignment")

Appendix 6.2: Content and delivery of educational materials found in a systematic search of the literature.

Author/Year	**Content from study**	**What**
		Procedures

d'Astorg 2020	N/A	Pre-op multidisciplinary consultation and instruction
Debono 2019	At our center, a 24-hour unit is dedicated to the support of ERAS care, has trained nurses, and is a place in which a patient briefing session is held once the intervention is scheduled (Fig. 1).33 The meeting with the surgeon is immediately followed by consultations with an anesthesiologist and physiotherapist (patient preoperative education). Then an ERAS nurse explains the pre- and postoperative stages of the procedure, as well as the prescribed home medication, and describes the main scenarios that can occur early after discharge. Nurses are on call to maintain a permanent telephone link with the patient at home. Before the patient is admitted to the hospital, he or she can consult online information about his or her future treatment and register online for hospital admission to limit excessive waiting the morning of his or her admission. Patient education was focused on the use of analgesics, with particular emphasis on avoiding the use of an opioid analgesic.28 Regarding the early home follow-up, a nurse from the ERAS team was available 24 hours a day by phone or a dedicated mobile application (app).6 One of the pillars of ERAS is to make the patient proactive (Fig. 5). Measures that could be considered anecdotal (standing patient, mobile app, etc.) force the patient to position him- or herself dynamically throughout his or her care.18 Education provided before and during	Following meeting the surgeon, a patient then meets with anesthesia and a physiotherapist , whom provide pre-operative education. An ERAS nurse then meets with the patient and explains the pre- and post-operative stages of the procedure. The nurse then educated the patient on prescribed medications, and describes the main scenarios that can occur following early discharge. Nurses are available via the phone to answer questions before and following surgery. An ERAS app is also available for the patient to contact a nurse 24/7 as well. Online patient information is also available to the patient. Post-operative education is focused on the use of analgesics, particularly why they try to avoid the use of opioids.

	hospitalization is essential to ensure the patient's safety in terms of both the functional aspect of physical activities that he or she can resume early on and the management of analgesics at home.3	
Debono 2021	The patient is repositioned as a stakeholder in his/her care: Because of his/her involvement before his/her surgery, educational measures make it possible to avoid positioning the patient in a passive attitude. Measures that could be considered trivial (standing patient, mobile app) force the patient to position him/herself in a proactive way throughout care. ACDFs most often have simple evolution, but ERAS seems promising in more complex conditions [29].	Following meeting the surgeon, a patient then meets with anesthesia and a physiotherapist , whom provide pre-operative education. An ERAS nurse then meets with the patient and explains the pre- and post-operative stages of the procedure. The nurse then educated the patient on prescribed medications, and describes the main scenarios that can occur following early discharge. Nurses are available via the phone to answer questions before and following surgery. An ERAS app is also available for the patient to contact a nurse 24/7 as well. Online patient information is also available to the patient. Post-operative education is focused on the use of analgesics, particularly why they try to avoid the use of opioids.

Duojun 2021	Preoperative health education includes not only traditional education (including admission education, dietary guidance, telling patients to stop smoking and alcohol, aspirin and other drugs, introducing safety precautions, giving psychological nursing, and instructing deep breathing and cough exercises), but also detailed oral and written education on diseases and surgical techniques. The operating room nurse introduces the operating room environment and operating position. The skin condition and vascular condition of the patients were evaluated. Psychiatrists can provide detailed personalized and professional psychological counseling and use anti-anxiety and depression drugs when necessary to improve the preoperative mental state of patients. Education Pre-operative education program + pre-operative counseling In this study, the patients of ERAS pathway were invited for consultation with psychiatrists after admission and preoperative comprehensive education mode to receive detailed personalized and professional psychological counseling, and anti-anxiety and depression drugs could be used if necessary to improve the preoperative mental state of patients and accelerate their recovery.	ERAS education includes traditional education and new material. Traditional education includes information on admission education, dietary guidance, smoking and alcohol cessation, and exercises on deep breathing and coughing. Oral and written education on surgical techniques also provided. Patients in the ERAS pathway also receive psychological counselling (or medication) to help reduce anxiety of the patient.
Flanders 2020	Patients were also provided with educational materials on protein nutrition and smoking cessation if applicable.	Education includes information on surgery and expectation management, as well as surgical site education. Patients were also provided educational materials on protein nutrition

		and smoking cessation as needed.
Garg 2021	The typical pathway of our ERAS protocol begins with patient education in the out-patient department when the option of surgery is offered to the patient. Comprehensive information is provided to the patient regarding the nature of surgery, potential complications, hospital stay, and timeline of anticipated postoperative recovery. Most importantly, the patients' expectations are tapered and realistic goals for recovery are set. Patient education - Patient explained regarding the treatment options and anticipated prognosis of the condition- Goals of treatment and subsequent recovery outlined- Provision of hand-outs of "frequently asked questions (FAQ)"- Testimonials of previously operated patients shared with the patient	Provided when the patient is offered surgery. Information surrounding the nature of surgery, risks of complications, expectations on hospital stay and timeline of anticipated recovery are provided. Expectation setting surrounding their recovery is set, goals for recovery are established, and other pre-hospitalization components are provided (such as exercise) in order to have a "productive use of waiting list time". A hand out of frequently asked questions is also provided, and includes testimonials from previously operated on patients are shared with the new patient.
Heathcote 2019	A clinical registered nurse served as the full-time ERAS surgical home manager. She coordinated implementation of the protocols with the anesthesiologist, surgeons, and operating room staff along and provided an in-depth preadmission education with the ERAS patient to review preoperative carbohydrate drinks, multimodality pain control, and postoperative expectations.	A registered nurse would provide education at pre-admission for the patient, and would review carbohydrate beverages, multimodal pain control, and post-operative expectations.
Li 2018	Preoperative education included the aim and procedure of the ERAS protocol, pain coping strategies, discharge criteria, and a follow-up plan.	Education includes information on the ERAS protocol and the aim of ERAS, pain coping strategies, discharge criteria and a follow-up plan.

	In our ERAS group, preoperative education introduced the aim and procedure of the ERAS protocol, pain coping strategies and details of the operation.	
Li 2021	Education Including the purpose, workflows and benefits of ERAS program, anticipated postoperative pain and expectations and risks of surgery, through verbal and handouts. Due to the decline in visual and auditory functions of elderly patients, the education was through verbal and handouts, with an emphasis of involvement of family members. Understanding the patient's expectations, preferences and the burden of postoperative care can help medical teams determine better treatment options to truly improve quality of life.	Including the purpose, workflows and benefits of ERAS program, anticipated postoperative pain and expectations and risks of surgery, through verbal and handouts
Smith 2019	To improve patient communication, a standardized education packet was given to patients in the neurosurgical clinic prior to surgery. This included information about the surgery, expectations, support services, management of diabetes, and smoking cessation among other things. At preoperative services, education was reinforced and patients underwent a laboratory workup, history and physical prior to surgery. ▪ Patient given information letter and materials including diabetes education and smoking cessation	A standardized package is provided to patients prior to surgery, and is given in clinic. This handout includes information on the surgery itself, expectations, support services available, management of diabetes, and smoking cessation.

	Incentive spirometry, OSA and CPAP education, NPRS education Our ERAS protocol focused on some of these expanded ideas to improve patient education and interdepartmental teamwork. Preoperative patient education has become an important part of improving patient care perioperatively. Educating patients about expectations postoperatively can improve postoperative patient satisfaction and decrease patient morbidities and pain scores after lumbar surgery (Archer et al. 2011) Information regarding fasting guidelines and day of surgery medication use has also been an issue for some patients in the past at our institution, so education on these topics was provided to patients verbally and in printed handouts prior to surgery.	
Wang 2022a	1. Education on smoking and excessive drinking cessation; available counseling services at any time; appropriate optimization of chronic disease in outpatient and inpatient settings; nutritional assessment and support	N/A
Wang 2022b	Patient education and counseling: in which the nurse explained the preoperative and postoperative stages of the ERAS procedure and benefits of the ERAS program as well as describing to the patient the main scenarios that can occur soon after their discharge from hospital	Describe pre-op and post-op phases of ERAS and the benefits of the program. Also explained the scenarios that can happen following surgery.

Chen 2022	Through preoperative education, patients can understand the mechanism and prevention of lumbar degenerative disease related pain and physical dysfunction and the relationship between pain, deformity, and dysfunction caused by the disease. Explanation of the operation procedure, anesthesia, nursing and rehabilitation process, possible difficulties, and corresponding action plan. Teaching patients the correct rehabilitation exercise method and self-assessment method through sensitization and education. Pre-ERAS: Explanation of the basic surgical procedure and the possible risks before patients are asked to sign the informed consent Good preoperative patient education can improve patient compliance, patient anxiety, and fear of surgery 3) Patients in the preERAS group who did not receive preoperative education and rehabilitation exercises had poor compliance with getting out of bed early after surgery.	N/A
Cui 2022	Education and counseling: Informing the patients about the risk of surgery, ensuring patients to learn and understand ERAS pathway	N/A

Appendix 6.3: Content of the educational packages from the Vancouver spine program, as per the TIDieR criteria.

Province/ Hospital/ University	**Materials and Procedures**

British Columbia/ Vancouver Spine surgery Institute	Online PDFs detailing five different components of ERAS, spine surgery, and the patient's recovery. The ERAS booklet is 82 pages long, the thoracolumbar booklet is 22 pages long, the back surgery procedures booklet is 32 pages long, a second thoracolumbar booklet which is 44 pages long, and a 2 page booklet on admission. https://vancouverspinesurgery.com/patient-information/ Main web page is provided as a URL, and directs educational material for the patient for preparing for surgery/admission, and information on the procedure they are going to receive.
	https://vancouverspinesurgery.com/wp-content/uploads/2022/03/Thoraco-Lumbar-Spinal-Surgery-Pre-Operative-Booklet.pdf A nurse and anesthesiologist will review your health records prior to your procedure, and will determine if you need a full pre-admission clinic appointment, or can just receive a phone call from the nurse on how to prepare for surgery. A support person is recommended to attend as well.
	https://vancouverspinesurgery.com/wp-content/uploads/2022/08/Discectomy-Laminectomy-Education-Booklet.pdf A booklet on the procedure being performed for the patient is provided, and an in person classroom session is also provided. It is recommended to take the booklet to both the class and to your surgery. Unlike the thoraco-lumbar PDF, this one stated to take the booklet to any pre-surgical screening, or to the pre-admission clinic. This booklet begins with an introduction setting expectations for the patient. Part of the introduction focuses on ensuring the patient knows they are an active participant in their own surgical process, saying "your role starts even before you come to the hospital", in regards to fitness and preparing your home for your recovery, and have a prepared support system (friends and family). After this, is a section on preparing for surgery. This section includes content on: Where the hospital is, what to do to prepare for surgery (pre-surgical screening, read the FAQ, do the telephone interviews), arrange for transport home, and plan for your discharge. The next section then provides information on what to bring (such as a health card, hearing and seeing aids, walking cane if needed, comfortable clothing) and what not to bring to the hospital (such as unnecessary money, pets, valuables or electrical appliances), as well as a list of general instructions (such as stop taking aspirin and manage diabetes prior to surgery. Lastly, in preparation for surgery, fasting instructions are provided, which states no solid foods

	after midnight unless otherwise instructed, no chewing gum, mints, candies or alcohol after midnight, and you can drink clear fluids (180mls) until 4 hours prior to surgery. The next section details what will happen on the day of surgery. Content included entails: Medications, diabetes, sickness (what happens if you're sick otherwise going to surgery), managing pain (types of anesthesia provided, pain management in the hospital, and patient controlled analgesia and epidural pumps), Following this are the steps of surgery, which includes: Admission to the surgical service care unit, details on the operating, recovery rooms as well as recovery in the daycare or on the hospital ward. Section two is covered next, and provides educational material on back surgery in general. It opens with the anatomy of the spine, and then covers common spine diseases, such as disc herniation, spinal stenosis, osteoarthritis, and then delves into how a microdiscectomy or a laminectomy addresses these pathologies. Following this, the booklet then has instructions on how to prepare your home, and what to expect following surgery. Following surgery, differences on types of pain are described (surgical pain vs nerve pain), and that pain following surgery is normal. Then nausea/vomiting, positions of comfort, activity, caring for the incision, toileting and exercises following surgery are covered. Follow-up appointments, and information on when to seek medical attention once recovering at home are then covered.
	https://vancouverspinesurgery.com/wp-content/uploads/2022/08/Discectomy-Laminectomy-Education-Booklet.pdf A booklet aimed at the thoracolumbar region of the spine. Provides education in a 44 page booklet, and also details information on the Vancouver General Hospital pre-operative education class. While the booklet is readily available as a PDF online, the spine education class is provided in person, with a specialized clinical nurse, and physiotherapist as well as an occupational therapist will deliver a class on how to prepare for surgery. The class is for a 3-hour period, and patient's attend the session 3-6 weeks prior to surgery. Content sections include: Mental preparation, pre-op exercise, smoking cessation, nutritional needs, diabetes management, managing illness prior to surgery, general information for patients and families, accommodations for patient's/caregivers in Vancouver, the spine clinic itself, the Vancouver General Hospital and the admitting department, pre-admission clinic, and the spine surgery pre-operative education class. The following sections relate to managing medications, how to prepare to return home (transport

	home, supports needed at home) and then bed management at the hospital during the inpatient stay. The next major section is on the inpatient stay: Includes information on the steps leading up to surgery, during and after, routine testing, rules in the hospital (no smoking and proper hand cleaning, what not to take with you), information on visitation, pain management, medications (and possible side-effects), nutrition, incision care, mobility, personal care, length of stay, cell phone and internet use as well as television and phone services, filling a prescription, and the discharge checklist. The checklist includes: Your pain is well managed, wound is healing, you can empty bladder and bowels, and can get out of bed and ambulate within reason around your home (including stairs). The final section focuses on at home care: Section includes information on pain management, incision care, signs of infection, changing wound dressing, removal of staples/sutures, metal detectors, activity guidelines following surgery, follow-up with your surgeon, parking at the hospital, and what to do in case of medical emergency.
	https://vancouverspinesurgery.com/wp-content/uploads/2014/08/Pre-Admission-Handout.pdf A two page document, describing information on the pre-admission clinic. Details where the clinic is and covers that a nurse and anesthesiologist will meet with you to review health history, your current medications and will discuss your planned surgical procedure. This interview can also be conducted over the phone with the nurse as well. A small infographic is found on page two detailing all the steps you will go through during surgery (meeting with your surgeon and being offered surgery, all the way through to discharge home).
	https://vancouverspinesurgery.com/wp-content/uploads/2022/08/ERAS-Thoraco-Lumbar.pdf https://www.youtube.com/watch?v=swXJ_7Gtqz4 https://www.youtube.com/watch?v=oPibGZPDlVE This booklet is 80 pages long, and details what enhanced recovery is, how to prepare for your surgery, and what to expect during your hospital stay with an ERAS program. The introduction begins with covering what ERAS is, and the program they have in Vancouver, and then provides some patient checklists (such as what to take to hospital, and things to prepare for when discharged home). The following section is on what to expect before your surgery, including how to prepare yourself (physical

	fitness for example), and what to expect with the pre-admission clinic. The next section details how to prepare for your surgery, including what to do a week out from surgery (such as stopping non-prescription supplements, and herbal teas), and the day before (when to stop eating/drinking, diabetes management, carbohydrate loading), as well as on the day of. A list of what can be consumed for food and beverages and the timelines are also provided. The next section details what you can expect during the hospital stay. Content includes what to expect during the surgery, the surgical waiting room, the post-anesthesia care unit, the spine stepdown/nursing unit, pain control (when to contact a nurse for supplemental analgesia), nausea/vomiting, eating/drinking (early nutrition for ERAS), deep breathing exercises, leg exercises, identifying blood clots, urinary tract infections, and personal care. Following this, specific details are provided on that the patient can expect on the day of surgery, and days 1-4 (until discharge) post-operatively. It then discusses the day you go home, and the patients follow-up visit. Before saying what to expect each day, there is content related to expectation setting, as not all patient's will recover at the same rate. Clear discharge criteria are listed, such as pain management with oral medication, able to eat without pain/bloating, able to pass gas and/or have a bowel movement, able to do basic activities you need to do at home independently, and there are no signs of problems with your surgery. There are then expectations set regarding feeling sleepy and sore following surgery. Possible recovery equipment is listed, such as breathing aids, intravenous fluids, dressing on the incision, and a back drain. Then expectations for each day are listed. For the day of surgery, following your surgery, pain will be managed with a PCA pump, Tylenol, and potentially opioids if required. ERAS protocols call for deep breathing and leg exercises in bed. Patients are to chew gum, and are encouraged to return to a regular diet as tolerated. On day 1, patients have activity goals, such as walking 20 meters twice in the day, and sit in your chair independently. Deep breathing and leg exercises to be continued, as is chewing gum. For day 1, regular diet is offered, and the nurse will check if the patient passed gas. Patient's should have an idea on what day they plan to go home. For day 2, the patient should be feeling stronger. If not removed on day 1, intravenous and pain pumps could be removed. Patient mobilization is set to ambulate 50 meters twice in a day, while continuing in bed and chair exercises. Day 3 follows the same criteria as day two, with another increase in ambulation to walking 100 meters twice in a day. The incision dressing is also changed on day 3, and you can have a shower. You should have arranged a pickup by 10:00am for the day you

	go home at this point. On day 4, you shouldn't require additional equipment or tubes. For ambulation, the patient should walk circuits around the inpatient unit at least twice. You should have a normal diet at this point, and drinking enough fluids to avoid constipation. You should be reviewing the "The day you go home" section of this booklet. The next section is about the day you go home. Once again, the discharge criteria are reiterated, and a plan for being transported home should be planned. Alternative arrangements with a hotel are listed if necessary. After this, your follow-up visit will be planned, and you will be provided medications you will need to continue your recovery. Next, expectations for what to expect at home are explained, regarding pain, wound care, bowel care, activity and exercise and when to seek help. For pain, non medication related therapy is recommended (hot/cold compresses), and warnings about narcotics. After this caring for the wound regarding washing and staple removal are listed. Dietary guidelines are then listed, regarding how much to eat and drink and ensuring a balanced diet. Then bowel care is covered, and discusses constipation and diarrhea. Activity and exercise are described, with a neutral spinal alignment emphasized during exercise. Various figures showing how to align the spine in a neutral posture are shown. Guidelines for lifting, and physical activity are provided. Sports and driving a car are subject to discussion between the patient and the surgeon, whereas normal sexual activity can resume as desired. Lastly, a brief list of situations where to seek medical attention are listed. Some examples include pain that can't be managed at home, a fever over 38.5 degrees Celsius, risk of infection of incision (red, swollen, hot to touch or a foul smell)., nausea and vomiting for >24 hours, no bowel function for 48 hours, or diarrhea for >2 days. A list of resources for various medical providers is then provided for home safety, health professionals, accommodations, equipment and transportation.