Exploring the Impact of the Covid-19 Pandemic on Canadian Wait Times for Elective Spinal Surgery

by

Taylor Smith

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Supervisor: Jeffrey Hebert, PhD., Faculty of Kinesiology

Examining Board: Jonathon Edwards, PhD., Faculty of Kinesiology, Chair

Niels Wedderkopp, MD., PhD., Department of Clinical Research, University of Southern Denmark

Gwyneth de Vries, MD., FRCSC, Orthopedics, Sport and Exercise Medicine, Faculty of Medicine, Memorial University & Dalhousie University

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ABSTRACT

Background: Increased waiting times for spinal surgeries can have detrimental effects on patients, and the impact of the Covid-19 pandemic is unknown. **Aim:** To identify the impact on wait time days for spine surgery of the Covid-19 pandemic and to quantify the number of patients awaiting surgery and surgeries being performed. **Study Design:** Longitudinal analysis of prospectively collected data. **Study Outcomes**: Days between surgical consultation to surgery (T2) and days between general practitioner referral to surgery (T3), the number of patients awaiting surgery, and the counts of spinal surgeries performed. **Data Analysis**: Quantile regression was used to identify median wait time days. Counts were used to report waitlists and surgeries. **Results:** The Covid-19 pandemic had a significant negative impact on both the national T2 and T3 wait times for elective and non-elective cohorts. Patients on the waitlist for both cohorts increased during the pandemic, and the number of surgeries being performed declined.

DEDICATIONS

This is dedicated to the people who have supported me throughout my academic journey, friends, family, classmates, professors, and mentors, you know who you are. I appreciate every one of you.

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Chapter 1: INTRODUCTION

Back pain is the leading cause of disability worldwide.[1,2] Lower back and neck pain are becoming more prevalent with an increase of 17.3% and 21.1% in global prevalence respectively, from 2005 to 2015.[1] This growing prevalence of back pain in the global population indicates a need for understanding of patient wait times to specialty care such as surgery. Some conditions of the spine require surgical interventions like decompression or fusion procedures. These procedures are performed on pathologies such as Degenerative Disc Disease, deformities, and disc herniations.[3]

Prolonged wait times for surgery can have negative consequences on a patient's quality of life. It can increase the potential of adverse events, be a detriment to physical and mental well-being, and in some cases result in a need for additional surgical interventions.[4,5] It is important to monitor surgical wait times as they are used as a metric to measure the quality of a health care system, how responsive the health care system is, and can indicate where resources need to be allocated.[6] Quantifying wait time information provides a sense of transparency and necessary information to health care providers, policymakers, and the public.

Canada continues to show concern for prolonged wait times within the health care system.[7] Canada has been ranked 9th out of 11 high-income countries for access to care, and 10th in equity and health care outcomes in the recent Commonwealth Fund 2021 'Health Care System Performance Ranking'.[8] As of 2021 the median waiting time to receive elective treatment within Canada was 25.6 weeks; one of the longest recorded wait times in Canada since 1993, when it was just 9.3 weeks. Importantly, the wait times were still 20.9 weeks on average in 2019, in pre-pandemic times.[9] Within Canada, there

is a large variation in wait times between provinces. In 2020, Ontario reported the shortest total wait time at 7.4 weeks, while Prince Edward Island reported the longest at 46.5 weeks. Additionally, the proportion of people waiting for treatment ranged from 1.97% in Quebec, to 9.97% in Nova Scotia.[9]

The declaration of a global pandemic by the World Health Organization (WHO) from an outbreak of the novel coronavirus (Covid-19) on March 11, 2020, only intensified the strain on the health care system in Canada[10]. During the pandemic, hospitals were required to shift resources for respiratory admissions due to Covid-19, such as ICU beds, ventilators, and staffing reassignments. These changes had a major effect on the surgical programs across Canada, the data shows that during the pandemic, an estimated 560,000 surgeries were cancelled or delayed over the first 16 months of the pandemic compared with 2019.[11] The pandemic has likely created discrepancies in the wait times from general practitioner to specialist assessments, and from assessment to surgery from pre-pandemic to mid-pandemic times. This demonstrates the need to establish new wait time statistics for many elective spinal surgical procedures across the country.

In this study we aim to examine the mean wait times for elective spine surgery in days, nationally and provincially pre-COVID-19 pandemic, and during the pandemic to date. We additionally aim to describe the number of patients waiting to receive spinal surgeries and the number of surgeries being performed before and during the pandemic. The information gathered in this study may help to inform health policy and resource allocation through the knowledge of national and provincial wait times.

LITERATURE REVIEW

Canadian Spine Outcomes and Research Network (CSORN)

The Canadian Spine Outcomes and Research Network (CSORN) is a registry created by the Canadian Spine Society to advance excellence of spine patient care through research. The CSORN registry was created to identify and assess the impacts of different interventions on various spinal conditions. The registry provides surgeons and medical practitioners across Canada the indications, interventions, complications, and outcomes of spine surgery. CSORN data is collected from 21 sites across the country with 53 participating surgeons as of 2020. Data from these sites include patient medical charts, history, and outcome measures such as disability, pain, and quality-of-life.[3]

The Canadian Spine Outcomes and Research Network categorizes spinal surgery procedures into four main types, fusion, decompression, discectomy, and other for both the thoraco-lumbar spine region and cervical spine region. Within these four surgical categories there are categories of principle pathologies that patients are primarily diagnosed with. For the cervical spine, the principal pathologies are disc herniations, degenerative disc disease, stenosis, and other. The thoraco-lumbar spine diagnoses include all the same pathologies with the addition of deformities and spondylolisthesis.[3]

Pathologies

Spinal Stenosis

Spinal stenosis is a chronic and potentially debilitating condition of the spine that typically effects older adults,[12] and is the most common indication for spinal surgery in people older than 65 years.[13] Spinal Stenosis is classified as a narrowing of the intervertebral foramina or spinal canal resulting in compression of the neural structures

such as the spinal cord or branching nerve roots that reside within and exit the canal. This compression can be due to degeneration or thickening of the surrounding soft tissues or bone.[14] Stenosis can present in both the cervical spine but is most prevalent in the lumber spine, and it is rarely present in the thoracic spine[15]. Stenosis may cause symptoms associated with radiculopathies, which is compression of the nerve root, or neurogenic claudication and potential disability, effecting the physical capacity of patient's everyday lives.[16,17,18,19]

Lumbar Spinal Stenosis (LSS) can be congenital or acquired. Congenital stenosis is an uncommon condition,[20] which is caused by abnormalities or disorders in postnatal development.[21] Acquired LSS is typically caused by degenerative factors due to aging, which include, facet joint hypertrophy, loss of intervertebral disc height, disc bulging, osteophyte formation, and hypertrophy of the ligamentum flavum. LSS may also be caused by excess scar tissue or proliferation of bone after surgery, infection, or trauma.[21] All of these factors may contribute to the displacement of nerve roots in the central canal or neural foramina where they exit the spinal column, causing adverse symptoms.[22]

The most recognizable manifestation with spinal stenosis is neurogenic claudication.[23] The symptoms of which are progressive onset of pain, numbness, weakness, and tingling in the low back, glutes, and legs, which is exacerbated by standing, walking, or lumbar extension.[24] In addition, the absence of pain when seated, and the improvement of symptoms when bending forward are used to aid in diagnosis. Patients with spinal stenosis nearly always present with lower back pain.[16]

There are no absolute requirements for a spinal stenosis diagnosis, but in the absence of valid objective criteria, it has been suggested that opinions of experts such as physicians with a careful review of history and physical examination, be considered the

"gold standard" in diagnosis.[25] Most inclusive studies require patients to have leg symptoms, either neurogenic claudication or radicular pain, and confirmation of stenosis by imaging.[18] Surgery is indicated with progression of intolerable symptoms or more urgent neurogenic complications.[4]

Degenerative Disc Disease (DDD)

The human spine is made up by the 23 intervertebral discs (IVDs) that articulate and anchor the vertebral bodies together. These discs act as shock absorbers and transmit loads from muscular activity and body weight to the spinal column, additionally they provide support and flexibility to the otherwise rigid spine.[27,28] There are no clear definitions for Intervertebral Disc Degeneration (IDD) but, disc degeneration refers to the structural or functional failure of the intervertebral disc because of abnormal pathological, cellular, and acellular changes.[29]

Degeneration proceeds in three steps, biomolecular damage such as inflammatory stress, leading to a dysregulation in cellular damage, finally leading to loss of structure and function of the disc.[28] This typically results in loss of disc height, instability of the spine at affected spinal segments, and increases functional disability of the spine.[30,31] Reported risk factors for disc degeneration are age, physical loading, genetic predisposition, injury, vibration, obesity, and environmental factors such as smoking, typically resulting from a combination thereof.[32]

The term Degenerative Disc Disease (DDD) is assigned to degenerative intervertebral discs that present with pain.[29,30] Patients typically present with mechanical lower back pain, made worse with forward flexion and when carrying heavy loads. Advanced degenerative disc disease can present with structural changes in the spine,

such as intervertebral disc bulge, disc herniation, thickening of the ligamentum flavum and facet joint hypertrophy, which can lead to spinal stenosis and ultimately neural compression.[33]

Degenerative disc disease is a leading cause of chronic back pain in the world among the aging population, although non-age-related degeneration is highly prevalent in the younger population.[34] Intervertebral discs appear to undergo age-related degenerative changes earlier in life than other tissues and it is the most common cause of joint-related chronic disability and debilitating pain in the elderly.[35]

Disc Herniation

Disc Herniation is a displacement beyond the intervertebral disc space of the internal nucleus pulposus contained inside the intervertebral disc, and is due to partial or complete rupture of the outer layer of the disc called the anulus fibrosis.[30] The herniation can occur in the anterior, lateral, posterolateral, or posterior directions which can cause compression of the neural structures running through the spinal canal, particularly in the latter two directions.[36] This compression can result in pain, weakness, and tingling in the extremities, and is the most common cause of sciatica.[37,38] Sciatica is characterized specifically by leg numbness, weakness, low back, and radicular leg pain, which can pose great functional disability on patients.[38,39]

Herniated lumbar discs are the most common diagnosis among degenerative conditions of the lumbar spine, and the main reason for surgery.[40] It has also been reported that protruded discs can be found in 20–30% of the general population.[41] The highest prevalence of herniated discs exist in people between the ages of 30-50,[42] among this population, 95% of herniations occur in the lumbar spine. Herniations are more

common in the lumbar spine than the cervical spine, possibly due to the higher risk factors of the lumbar spine such as loads, posture, and workplace stressors as opposed to posture being the main risk factor for cervical disc herniations.[43] Although possible, herniation rarely occurs in the thoracic spine.[44]

Spondylolisthesis

Spondylolisthesis refers to the translation of one vertebral segment in relation to another segment of the spine.[45] There are various methods of classifying spondylolisthesis, but the Meyerding classification grade based on severity of translation is a reliable measure used in diagnosis.[46] Type 1 and 2, are considered low grade spondylolisthesis, characterised by a less than 50% translation of the vertebrae. Types 3,4, and 5 are considered high grade spondylolisthesis and are characterised by a greater than 50% translation.[46,47]

There are different subtypes of spondylolisthesis, those with spondylolysis either isthmic or dysplastic which is characterized by a fracture or defect of the pars interarticularis or facets of the vertebra,[48] caused by congenital, pathological, or traumatic factors. Lastly, degenerative spondylolisthesis, caused by a degeneration of the vertebral structures, which is one of the most encountered spinal conditions.[49,50]

Most often spondylolisthesis is asymptomatic, when symptoms do occur, for adults with degenerative spondylolisthesis they may present with lower back pain, radiculopathy, or neurogenic claudication, and with worsening of the condition can present with potential bowel and bladder symptoms, and severe cases, cauda equina syndrome, all from neural compression.[51,46]

The prevalence of Spondylolisthesis is typically higher in adult women[56], rarely occurs before the age of 50,[53] and most frequently occurs at L4-L5, followed by L5-S1.[54] Surgery is usually recommended for patients with low-grade slips which are unresponsive to conservative treatments, and for all high-grade translations.[47] Indications for surgery are like those made by other pathogenetic factors causing spinal stenosis or instability.[48]

Inflammatory Spine Disorders

Inflammatory spine disorders are a group of systemic pathologies that have a spinal involvement, these fall into two categories, Rheumatoid Arthritis (RA), and Spondyloarthropathies.[55] Concerns about spondyloarthropathies can be associated with many systemic disorders but the main concern is to treat secondary mechanical consequences of the original rheumatic pathology such as instability or deformity of the spine, and neurological deficits.[55] The two most common inflammatory spine disorders that require surgical interventions are RA and Ankylosing Spondylitis (AS).[55,56]

Rheumatoid Arthritis is a chronic, systemic autoimmune disorder that involves all the joints of the body including the 32 synovial joints of the spine and it is the most common inflammatory disorder affecting the spine that affects 1-2% of the general population.[57] Although RA can be present in the entire spine, it is typically of clinical concern in the cervical spine. Up to 80% of RA patients present with cervical spine involvement, which can lead to erosion of bone, ligament laxity, and ultimately spinal instability.[58] RA can remain asymptomatic, although it typically presents with high neck or occipital pain, but only 7-30% of RA patients have neurological deficits.[59] Lack of neurologic presentation and poor correlation between pain and subluxation of the joints in

the cervical spine presents a major concern for sudden myelopathy or in extreme cases, death due to neurologic or vascular compression.[60]

Ankylosing Spondylitis (AS) is another chronic inflammatory disease that effects the spine and the sacroiliac (SI) joints and it is prevalent in up to 1% of certain populations.[61] AS is characterized by damage and ankylosis (fusion) of the SI joints and vertebrae of the spine, leading to reduced mobility and pain.[56] AS is more common in men than women and onset of the condition typically occurs between the ages of 30-50, but can occur earlier in life.[62] The etiology of AS is unknown, but it has been shown that 90% of AS patients contain a similar gene, as opposed to only 15% of the rest of the population.[56]

The hallmark of AS is sacroiliitis, inflammation of the sacroiliac joints, and painful inflammation of the entheses, the points of union between soft tissue and bone. AS may present with back pain and stiffness, especially in the morning, limited lumbar range of motion, and limited chest expansion as the ankylosing progresses up to the thoracic spine, and in later stages if the entire spinal column fuses, it is known as "bamboo spine." AS patients are also susceptible to fractures as the disease progresses.[62] These are all presentations that can be used for diagnosis, along with MRI and clinical examination.

Deformities

Spinal deformities can occur due to several etiologies. There are three main deformities of the spine, which are scoliosis; a three-dimensional deviation of the spinal axis, kyphosis, and lordosis deformities, which are an extreme deviation from the natural anterior or posterior curves of the spine. Spinal deformities can be caused by degenerative changes, muscular imbalances, trauma, post-surgical complications, congenital reasons, or idiopathic if no other etiology can be found.[63]

Scoliosis is classified as a greater than 10° spinal curvature, measured using the Cobb angle, and can affect any part of the spinal column and Scoliosis can present in all ages but is classified as adult scoliosis over the age of 18 and is one of the most common adult deformities of the spine.[64] Scoliosis is prevalent in up to 20% of the adult population, rising to over 60% in those over 60 years of age.[65] Patients with scoliosis can present with pain, specific or non-specific, at the site of curvature either at the apex or in the concavity. The pain can be caused by facet joint irritation, muscular fatigue, or joint instability around the curve. Other symptoms can include radicular pain or myelopathy caused by nerve root or spinal cord impingement, or more severe neurological deficits in extreme cases.[64]

Hyperkyphosis is another clinically relevant adult spine deformity that is prevalent in the older, female population. Hyperkyphosis is an excessive anterior curvature of the spine, also measured using radiography, and characterized as having a greater than 40° Cobb's angle. This deformity can lead to functional limitations, musculoskeletal changes, and pulmonary detriments leading to higher mortality. Risk factors include reduced mobility, muscle weakness and sensory deficits, causing a decline in upright posture, spinal fractures, and degenerative disc disease.[66]

Lumbar lordosis would be an exaggerated increase or decrease of the lordotic curve in the cervical, but more commonly the lumbar spine. There is a lack of consensus on how to define lumbar lordosis due to a lack of consistent measurement methods, but it is shown that a loss of lumbar lordosis has been a strong predictor of low back pain in patients.[67]

Surgical Procedures

<u>Decompression</u>

Decompression surgery is a procedure whereby the neural structures of the spine are relieved of compressive forces placed by surrounding tissue. Safe decompression surgery of the spine includes a preservation of the neural structures being decompressed in addition to maintaining the segmental stability of the spine.[68] Decompression procedures include open, conventional, and microscopic approaches and are performed by neurosurgeons and orthopaedic surgeons. The most common indications for decompression surgery are herniated discs and spinal stenosis.[69]

There are multiple different decompression procedures and techniques used according to surgeon preference, pathology, severity of clinical diagnosis, and many other factors. The major different decompression procedures include microdiscectomy, laminectomy, laminotomy, laminoplasty, foraminotomy, corpectomy.

Laminectomies are a common surgery for spinal stenosis, a narrowing of the spinal canal or intervertebral foramina, in both the cervical and lumbar spine. This procedure involves removal of a section of the lamina - the posterior boney portion of the vertebrae, to relieve compression on the neural structures. This procedure may be accompanied by fusion surgery where the remaining bone structures are connected back together for stability with rods and screws, especially with patients presenting with spondylolisthesis.[70] A laminotomy is a less invasive procedure where the surgeon thins parts of the lamina to create more space for decompression, the spinous process, supraspinous and interspinous ligaments are preserved. This technique is preferred to a laminectomy to preserve stability in the segments and has a lower incidence of complications.[71] Lastly, a laminoplasty consists of two incisions on either side of the lamina to relieve neural pressure in the spinal canal, creating a hinge, and a space in the lamina where bone, metal or plastic is inserted to hold the spinal canal open.

Laminoplasty is more often chosen for the cervical spine because of presumed cervical spine stability, faster recovery time, and better functional outcomes.[72]

Discectomy is a procedure that consists of removal of some disc material that may be compressing neural structures. For lumbar disc herniations, Open Lumbar Microdiscectomy is considered the 'gold standard' surgical procedure. Although open discectomy is the gold standard, recent research has shown that minimally invasive surgical procedures such as microendoscopic discectomy (MED) and percutaneous endoscopic discectomy (PED) provide less tissue damage and could be beneficial in shortened hospital stays, and quicker return to work. Additionally, minimally invasive techniques require a demanding learning curve for surgeons.[73,74]

A foraminotomy is performed by removal of part of the vertebrae surrounding the neural foramen – the canal where the nerve roots exit the spine. This procedure is indicated for pathologies causing foraminal stenosis leading to radiculopathies, possibly due to loss of disc height, osteoarthritic degeneration, buckling of the ligamentum flavum or protrusion of the annulus fibrosis.[75] Foraminotomies can be performed as an open or a minimally invasive procedure as well, with minimal difference in outcomes between the two.[76]

A corpectomy is indicated when lesions in the anterior cervical spine cause neurologic deficits cannot be treated with alternative approaches such as a laminectomy. A Corpectomy procedure is the excision of typically a single vertebra and their adjacent disc spaces but can be a maximum of four vertebrae if affected. The procedure usually is accompanied by a reconstructive procedure that includes insertion of a strut graft or prosthetic device and possible further need for a fixation device.[77]

Fusion

Surgical spinal fusion is an effective treatment method used to stabilize segments of the spinal column that may be causing pain and suffering, correct spinal deformity, restore lordosis in the lumbar spine, and alleviate neurological deficits caused by spinal pathologies.[78,79] Lumbar spinal fusion is the most common spinal fusion procedure and is typically indicated with degenerative pathologies of the spine, and less commonly, traumas such as fractures or tumours which have metastasized.[80] There are multiple spinal fusion procedures categorized by the anatomical route taken to access the spine.

The traditional open surgical approaches include the anterior lumbar interbody fusion (ALIF), the posterior lumbar interbody fusion, (PLIF), posterior intertransverse fusion (PLF) and transforaminal lumbar interbody fusion (TLIF). More recently, minimally invasive surgical (MIS) techniques have arisen such as the endoscopic-ALIF, mini-ALIF, MIS TLIF

And the extreme-LIF (XLIF).[81] The type of procedure performed depends on surgeon preference and are classified and named according to the surgical route chosen.

Spinal fusion is the process of using bone graft, either from the patient or another source, to fuse two segments of bone together called arthrodesis. This is done in conjunction with instrumentation during surgery. The instrumentation is meant to provide additional stability to allow the bones to fuse together. Types of instrumentation include Pedicle screws, cages, artificial discs, rods, plates, and other spinal implants made from titanium, stainless steel, or non-metallic materials.[82]

Impact of Surgical Wait Times on Spinal Conditions

It is not only inconvenient for patients waiting to see a specialist or receive surgery, but prolonged wait times for these services can also have detrimental effects on even currently stable conditions. During a review of the literature, I found key studies that support that prolonged wait times for spinal surgery can have many negative impacts on the quality of life for patients including prolonged pain and suffering, poor surgical outcomes, and psychological distress.

Bailey et al., found in their perspective observational study of 166 patients who underwent spinal surgery for degenerative spinal stenosis that all health-related quality of life (HRQoL) measures decreased during both wait time groups of less than 12 months, or greater than 12 months of waiting, indicating pain and suffering would be prolonged the longer the wait time for surgery. This study had primary and secondary outcome measures such as the SF-36, Oswestry Disability Index, Zurich Claudication Questionnaire, and back and leg pain scores to compare groups for post-surgical outcomes at pre-operative and three post-operative time points over 2 years following surgery.

To describe the measures used in this study and multiple other studies, the 36-Item Short-Form Health Survey (SF-36) is a valid, generic, multidimensional self-reporting health questionnaire used for patients undergoing spine surgery.[83] The Oswestry disability Index is a reliable 10-question survey that assesses physical disability aside from back and leg pain.[84] The Zurich Claudication Questionnaire assesses the severity of spinal stenosis symptoms, both measures denoting higher scores associated with increased disability.[85] Back and leg pain are measured using numeric scales of 0-10, lower scores equating to less severe symptoms.[86]

The Canadian study by Bailey et al., showed at the 6-month follow-up patients who had waited less than 12 months to receive treatment demonstrated greater improvements in their primary outcomes of the SF-36 by a mean score improvement of 2.2 in the physical component and 4.5 in the mental component, the Oswestry Disability Index by -8.5, and secondary outcomes of Zurich Claudication Questionnaire scores improved by -.3, and leg pain improvement of -1.4, when compared to the patients who waited longer than 12 months to receive surgery. The positive changes denote improvement in the SF-36 and the negative mean changes indicate improvement in the remaining measures. At the 12 month follow up, all but the Zurich Claudication Questionnaire scores remained significantly improved in the shorter wait time group. Although HRQoL measurements deteriorated regardless of wait times, longer wait times were associated with delay in recovery during the first year after surgery.[87]

Another prospective longitudinal study by Baybrooke et al., found similar results in patient-derived functional pre-operative baseline to post-operative outcome measures of 53 patients undergoing posterior lumbar spinal surgery for degenerative spinal disorders. This study found significantly greater improvements in patients who waited less than the median total wait time for surgery, which was 196 days. Statistically significant observations were found in the SF-36 domains of bodily pain, general health, role physical, vitality, and physical component scores (PCS) between the shorter and longer wait time groups. The most notable in the PCS, general health, and role physical domain scores with Hazard's ratios of 3.53, 2.34, and 2.31 respectively. In addition to multiple SF-36 score findings, 40% of participants believed that their wait time negatively impacted their clinical condition, as well as their physical and mental wellbeing.[88]

In a Canadian observation of the effects of waiting times on pain intensity after surgical lumbar discectomy patients, Quon et al., concluded that a waiting time of 12 weeks or longer was associated with a higher likelihood of experiencing higher pain intensity on an ordinal scale, six months post-surgery, with a proportional odds ratio of 1:1.8 in the short (<12 weeks) and long (>12 weeks) wait time groups.[89] This means the longer wait time group was 80% more likely to report a higher pain intensity.

Regarding the onset of symptoms, two North American prospective studies on patients who underwent surgery for herniated discs show significant results supporting negative consequences for longer wait times for spinal surgery. Rihn et al., found that patients who experienced symptoms for more than six months before surgery had significantly worse outcomes than those who waited less than six months from the onset of symptoms. For primary outcome measures of the SF-36 for bodily pain domain, the physical function domain, and the Oswestry Disability Index the improvement for patients who had symptoms for six months or less remained significantly greater at all follow-up time points between 1-4 years, when compared to baseline values. All primary outcome scores were improved in the < 6-month symptom group at all follow-ups from 6 weeks post-surgery to 4 years, although not all were deemed significant findings.[90]

Jansson et al., found that in a population of 263 patients that underwent surgery for lumbar disc herniation, a duration of leg and back pain of more than six months was a risk factor for a worse health-related quality of life (HRQoL) as determined by the EuroQol-5D tool. The two groups differed with a mean score improvement of 0.08 for leg pain and 0.09 for back pain in the patients who had pain for less than six months.[91]

Additionally, in a study of patient-related factors predicting the outcome of decompressive surgery for degenerative pathologies on 280 patients with disc

herniations or spinal stenosis, Jonsson concluded that a longer than 6-month preoperative duration of sciatica was associated with poor postoperative outcomes at the two-year follow-up.[92]

In addition to waiting for elective spinal surgeries for degenerative conditions, a study examining empirically derived maximal acceptable wait times for the surgical outcomes of adolescent idiopathic scoliosis determined that patients who waited six months or longer for surgery were more likely to need additional surgeries and had an increased odds of having an adverse event such as progressed curvature of the spine, longer, more invasive surgeries, and longer hospital stays.[5] Another study for pediatric spinal deformities shows a deterioration in physical and mental health, self-image, and patient satisfaction with prolonged waiting times.[93]

Not only are objective manifestations of declining health a concern with longer wait times, but patients have been shown to perceive and attribute these wait times to moderate or significant deterioration of their overall health.[94] Mental and emotional stress are prevalent among patients waiting for care. For example, a subjective study measuring Health-related quality of life (HRQoL), patients report feelings of anger and frustration at the healthcare system, increased psychological stress and anxiety, a sense of uncertainty about their future and an inability to plan their lives.[95]

It is clear from the evidence outlined above, prolonged wait times for elective spinal procedures present negative consequences and prolonged suffering to patients suffering from degenerative spinal conditions. The studies above demonstrate that shorter wait times when compared to their longer counterparts equate to improved post-surgical outcomes regarding pain, functionality, and multiple domains of quality of life and may help to avoid unnecessary negative consequences. Whether prolonged wait

times result in poor post-surgical outcomes, a decline in the overall clinical condition, or psychological stress, all these consequences result in unnecessary pain and suffering for patients which could be reduced or avoided with knowledge and goals of wait times for best outcomes for elective spinal procedures.

Covid-19 Pandemic on the Health Care System in Canada

The World Health Organization declared the novel Coronavirus the second official pandemic of the twenty-first century on March 11th, 2020.[10] Coronavirus Disease 2019 (Covid-19) is caused by a Severe Acute Respiratory Distress Syndrome Coronavirus-2 (SARS-CoV-2), presenting a wide array of symptoms ranging from asymptomatic, acute severe respiratory distress syndrome (ASRD), to death.[96] According to the World Health Organization, since its origin in Wuhan, China, where the first cluster of cases were identified, there have been over 585 million cases of Covid-19 worldwide, and almost 6.5 million cumulative deaths to date.[97]

As the declaration of a pandemic swept fear and uncertainty across the nation, global leaders and civil servants were forced to act in attempts to control the spread of infection among their communities. Many countries quickly implemented mask mandates, social distancing, self-isolation, travel bans, lockdowns and perhaps one of the key implementations that persists for many countries including Canada, was the strain it placed on the healthcare systems.[98] Facility preparation and reallocation of resources such as staff, personal protective equipment (PPE), and medical equipment such as beds and ventilators left many areas of healthcare lacking the resources they needed to function at pre-pandemic levels.

One immediate measure to prepare for the influx of infected Covid-19 patients was the cancellation and postponement of elective surgical procedures. In March of 2020 the ministry of health requested all Germany hospitals to postpone elective surgical procedures with discretion of treatment left to the treating surgeon.[99] Additionally, on March 13th, 2020 the American College of Surgeons released its recommendation to "minimize, postpone or cancel electively scheduled operations."[100] Followed by many other countries, these postponements and cancellations were estimated by epidemiological modelling to reach 28 million procedures to be cancelled or postponed globally throughout the peak of the pandemic.[101]

Similarly, Canada followed suit and in early 2020 and proceeded to cancel or postpone many 'non-emergent' procedures and capacity was limited to life-or-limb surgeries. By March 15th, 2020, Ontario hospitals took action to cancel elective surgeries to increase the availability of acute care beds. This led to a cancellation of more than 50,000 hospital procedures in Ontario alone.[102] In British Columbia, by May of 2020 an estimated 30,000 non-urgent procedures were postponed or put on a waitlist and an additional 24,000 people would be left without referral for procedure.[103]

As provinces have begun to return to their pre-pandemic procedure capacity a back log of elective surgeries remains in Canada due to the multiple closures and reduction in care throughout the numerous waves of Covid-19. In Quebec, the most recent data shows that in the aftermath of the pandemic at least 160,000 residents are waiting for elective surgery. Nova Scotia Health has an estimated 27,000 patients waiting for surgery along with more than 70,000 Albertans. In Ontario - the most populous province in Canada, the wait list has grown to be between 225,000 to 250,000 patients.[104]

Many provinces have or are planning to implement plans to eliminate the surgical backlog in the months and years to come by pouring millions of dollars into the healthcare system and increasing the number of surgeries performed. They will do this by expanding and optimizing operating room hours, making use of regional surgical sites, and performing additional surgeries and types of surgeries through third-party contracts.[103,105,106] Although provinces are taking steps to clear the surgical backlog that has grown tremendously within Canada, these plans may take years to become affective leaving thousands of Canadians on the waitlist for surgery prolonging their suffering and further vitiate their quality of life.

There is a dearth of information regarding wait times for spinal procedures in the wake of the Covid-19 pandemic. In a 2021 report from the Fraser Institute, patients were shown to wait longest from general practitioner referral for neurosurgery and orthopaedic surgery compared to other specialties, at a median wait time of 49.2 and 41.6 weeks respectively.[107] This indicates that elective spinal procedures may be at risk for longer wait times within Canada compared to other surgical procedures.

There are currently no set benchmarks or best outcome wait time guidelines for elective spinal procedures like there are for procedures such as joint replacements set by Canada first ministers in 2005 which is 6 months from the date of treatment agreement between physician and patient.[108] It is crucial to quantify the waiting times for elective spinal procedures and to identify the effects of the Covid-19 pandemic on these wait times to establish a need for a new baseline for improving time to surgery for spinal procedures, as the backlog will likely cause a snowball effect in the years to come. Patients who are stable and considered mild or moderate in their disability will likely

become worse with time, indicating a need to establish a best outcome for elective spinal surgeries.

Given the information above and the substantial impact the Covid-19 pandemic has already shown to have on the surgical programs in Canada, it is not unsuspected that there will be an impact specifically on the wait times for elective spinal procedures. It is important to establish the magnitude of impact the pandemic had on these elective spinal procedures so that Canada can aim to diminish the resulting surgical backlog and re-establish a baseline to determine how to minimize the wait time and suffering for Canadians waiting for treatment.

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Exploring the Impact of the Covid-19 Pandemic on Canadian Wait Times for Elective Spinal Surgery

Taylor Smith
Bachelor of Science in Kinesiology, University of New Brunswick 2022

Corresponding author: Taylor Smith, University of New Brunswick, Faculty of Kinesiology, Fredericton, New Brunswick, Canada, Phone: (902) 637-8578; E-mail: taylor.smith96@unb.ca

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Level of Evidence: (2)

Mini Abstract/Précis

We explored the change in spinal surgery wait times for patients across Canada due to the Covid-19 pandemic, the number of patients waiting for surgery and the number of surgeries performed over time. We found nationally there was an increase in the wait times for both elective and non-elective cohorts. Similarly, there was an increase of patients waiting for surgery, and inversely, a decrease in the number of surgeries performed for both cohorts.

ABSTRACT

Study Design: Longitudinal analysis of prospectively collected data.

Objective: To examine the impact of the Covid-19 pandemic on wait times for spinal surgery patients in Canada and quantify the number of patients waiting and spinal surgeries performed.

Background Data: Increased waiting times for elective spinal surgeries can have detrimental effects as well as prolong the pain and suffering of patients, but the impact of the Covid-19 pandemic is unknown.

Methods: We included data from surgical candidates seen at one of 22 orthopaedic or neurological surgical centers across Canada. Study outcomes included wait times from surgical consult to surgery (T2) and from general practitioner to surgery (T3), counts of patients on the waitlist and surgeries performed. These outcomes were measured in 3-month time intervals starting from March 01, 2018, to February 01, 2022. All cohorts were stratified by severity of their clinical condition as 'elective' or 'non-elective'. Quantile regression was used to model the national change in T2 and T3 median days over time. We reported counts for patients waiting for surgery and surgeries performed.

Results: The Covid-19 pandemic had a significant negative impact on both the national general practitioner referral to surgery, and surgical consultation to surgery wait times for both elective and non-elective spinal surgery cohorts. The number of patients on the waitlist for both surgical cohorts nearly doubled during the pandemic, and the number of surgeries being performed during the pandemic fell.

Conclusion: Evidence suggests a negative impact from the Covid-19 pandemic on wait times for both elective and non-elective spinal surgery cohorts, as well as a general trend

of increasing waitlists and decreasing spinal surgeries being performed. These findings can help inform future healthcare policies in the event of another wave of the Covid-19 pandemic or help to decrease the backlog of spinal surgeries. Future research should focus on the negative impact of prolonged wait times on spinal conditions.

Key Points

- This longitudinal study of 6,913 patients found that during the Covid-19 pandemic, there was a national increase in the consultation to surgery (T2) and referral to surgery (T3) wait times for ‘elective’ and ‘non-elective’ surgical cohorts at the time of the pandemic.
- The ‘elective’ surgical cohort T2 wait times increased to above the recommended 182-day benchmark for best outcome of elective orthopaedic surgeries during the pandemic.
- During the pandemic, there was a national rise in the number of patients on both the ‘elective’ and ‘non-elective’ surgical waitlists from pre-pandemic numbers.
- During the pandemic, there was a national decrease in the number of elective surgical procedures performed compared to before the onset of the pandemic.

Chapter 2: INTRODUCTION

Prolonged wait times for surgery can have negative consequences on a patient's quality of life.[1] This can increase the potential of adverse events, be a detriment to physical and mental well-being, and in some cases, result in a need for additional surgical interventions.[1,2] Therefore, it is important to monitor surgical wait times as they are an indicator of the quality and responsiveness of a healthcare system and can demonstrate where resources should be allocated.[3] Quantifying wait time information provides a sense of transparency and necessary information to health care providers, policymakers, and the public.

The declaration of a global pandemic by the World Health Organization (WHO) from an outbreak of the novel coronavirus (Covid-19) on March 11, 2020, intensified the strain on the healthcare system in Canada.[7] During the pandemic, hospitals shifted resources to account for increased respiratory admissions due to Covid-19, such as ICU beds, ventilators, and staffing reassignments. These changes had a major effect on the surgical programs across Canada, the data shows that during the pandemic, with 560,000 surgeries being cancelled or delayed over the first 16 months of the pandemic compared with 2019.[8] The pandemic has likely created discrepancies in the wait times from general practitioner to surgery, and from consultation to surgery from pre-pandemic to mid-pandemic times. This potential negative effect due to the onset of the pandemic demonstrates the need to establish new wait time statistics for many spinal surgical procedures across the country.

Therefore, we aimed to quantify the waiting times experienced by spine surgery candidates before and after the onset of the COVID-19 pandemic. Specifically, objective

one was to model the median times from consultation to surgery (T2) and referral to surgery (T3). Objective two was to describe the number of patients waiting and the surgeries performed. This information may help to inform health policy and resource allocation through the knowledge of national and provincial wait times and waiting lists.

METHODS

Study Design:

This retrospective cohort study used patient data from the Canadian Spine Outcomes and Research Network (CSORN) data registry, it was analyzed in 3-month intervals starting in March 2018 to February 2022. We included patients who had a surgical consult from a participating surgeon and patients who received elective spine surgery as per the inclusion criteria from March 2017 to February 2022 from participating sites across Canada.

Participants:

We included all patients enrolled in the CSORN data registry, including males and females over the age of 18 (or the provincial age of majority), who have been deemed surgical candidates on or prior to March 01, 2017.

We categorized patients by the severity of their clinical condition. By surgeon recommendation, we considered patients with myelopathy, fracture, infection, tumour, inflammatory spine disorder, spondylolisthesis types 4,5, and 6, or motor impairments, as ‘non-elective’. The remaining patients who do not present with any of these serious symptoms are categorized as ‘elective.’

Ethics approval:

The nationwide CSORN project was approved at each spine center by their local Research Ethics Boards. Ethical approval for the current analysis was provided by the Horizon Health Network (2020-2962) and the University of New Brunswick (2021-520) research ethics board. All patients provided written informed consent to participate before study enrolment.

Outcomes:

For objective 1 we modeled the median days between the date of either general practitioner referral (T3) or surgical consultation (T2) and the date of surgery in each time interval for the 'elective' and 'non-elective' cohorts. For objective 2 we quantified the number of patients awaiting surgery after being identified as surgical candidates by their attending spine surgeon for each cohort. Additionally, we quantified the corresponding counts of surgeries being performed at each time point for both cohorts.

Data Analysis:

We generated descriptive statistics for all demographic (age, sex, education level, body mass index), clinical (pain intensity, disability), and surgery-related variables (fusion or non-fusion). We reported mean and standard deviations for normally distributed continuous variables and median and interquartile range for non-normally distributed continuous variables. We used counts and percentages to report categorical variables.

To examine for differences in median wait times across the 3-month time intervals (from March 2018- February 2022) we constructed median regression models to account for the positively skewed distributions of the outcomes. All analyses were stratified by severity of the clinical condition and reported on the national as well as the provincial levels when there were sufficient data available. The parameter of interest in the national models was the produced medians with 95% confidence intervals. We used these medians to identify statistically significant differences between the baseline in March 2018.

To describe the number of patients waiting for spine surgery and the number of surgeries performed, we reported the count of patients and surgeries performed in each of the 3-month time periods. All results were stratified by geographic region (national and provincial) and disease severity (non-elective and elective).

RESULTS

We included data from 6,913 patients and 22 neurological and orthopedic surgical centers across Canada (Figure 1). 4429 patients were classified as 'elective' (52.4% female), and 2431 as 'non-elective' (42.9% female), with a mean (SD) age of 58.8 (14.6) and 58.5 (13.5) years, respectively. Table 1 reports the preoperative demographic, clinical, and surgical information from the sample population.

Time from consultation to surgery (T2)

Elective surgery

National T2 waiting times for elective surgeries increased at the onset of the Covid-19 pandemic in March 2020. T2 times eventually decreased at 9 months post-pandemic

onset, resuming a more stable pre-pandemic trend (Figure 2.). There were significant differences (P<0.05) found at 3 months before the onset of the pandemic (P<0.01) with an increase of 52 days from the median baseline of 108 days in March 2018. There was an increase in T2 days at the onset of the pandemic (March 2020), and in the 3 months following with an increase of 148 days (P<0.01) and 153 days (P<0.01) respectively. At 6 months after the onset of the pandemic a decrease in T2 days was observed at only 102 days (P<0.01) above the baseline. Finally, 9 months post-pandemic onset, the T2 time decreased to an average of 74 days which was -34 days (P=0.013) less than the baseline T2.

Non-elective surgery

There is a similar trend with the national T2 waiting times for non-elective surgeries as the elective surgeries. A gradual increase in days from the baseline T2 in March 2018 can be seen in the months leading up to the onset of the pandemic, with a significant increase of 69 days (P<0.01) at 3 months prior and 72 days (P<0.01) at the onset in March 2020. 6 months post-pandemic onset, the T2 wait time days return to near pre-pandemic levels.

Provincial analysis:

There were heterogenous trends between provinces (Figure 4.). All provinces, except for Ontario, saw an increase in elective surgery T2 waiting times at the onset of the pandemic, with larger increases in New Brunswick, Quebec, and Manitoba. There were no common provincial trends for the non-elective T2 waiting times.

Time from referral to surgery (T3)

Elective surgery

T3 National elective wait times hovered around an average median value of 329 days in the months leading up the pandemic. There was a significant increase 3 months prior to the onset of the pandemic, at the onset of the pandemic, as well as 3-, and 6-months after the onset of the pandemic by 116 days (P=0.001), 164 days (P<0.01), 171 (P=0.013), and 94 days (P=0.031) respectively in reference to the baseline T3 wait times in March 2018. T3 wait times returned to similar pre-pandemic numbers at 9 months post-pandemic onset through to February 2022.

Non-elective surgery

Similar trends as the elective T3 wait times are seen in the non-elective surgery cohort. There is a gradual increase from the average median T3 of 182 days pre-pandemic onset, with significant increases at 6 and 3 months before, and March 2020 of 80 days (P=0.027), 127 days (P=0.002), and 198 days (P<0.01) respectively. There is a slight decrease at the 3 months post-pandemic onset at 151 days (P=0.19) more than baseline T3 of 167 days. There is a large decrease in days 6 months after the onset of the pandemic at -87 days (P=0.046), before returning to pre-pandemic wait times. (See Figure 5)

Provincial analysis:

There was heterogeneity found of the T3 median wait times between the provinces. An increase in elective T3 waiting times at the onset of the pandemic can be seen in NB, QC, MB, and AB, as well as an increase in BC just before the onset of the pandemic.

Counts of patients and surgeries

Elective

The number of patients on the waitlist for elective surgeries showed a slight decrease to the lowest number of patients waiting in the two-year period from March 2018 to 2020

at 480 patients. The national wait list increased in the months during the pandemic to 873 patients for elective surgeries in September 2021.

While the number of patients on the waitlist increased after the onset of the pandemic, the number of elective surgeries being performed appeared to decrease from 289 in March 2020 to its lowest value of 72 surgeries performed in September 2021.

Non-elective

There is a similar increasing trend in patients on the waitlist for non-elective surgery after the onset of the pandemic. At its lowest wait list number of 180 in March 2020 the non-elective surgery patient waitlist climbed to 370 patients waiting by September 2021.

Like the elective surgeries performed, there was a decrease in the number of non-elective surgeries performed starting at 138 surgeries in March 2020 with a drop to 74, 3 months after the onset of the pandemic. There was a small increase and remained at an average of 93 surgeries performed until dropping to just 61 in September 2021. (See Figure 2)

Provincial:

There was heterogeneity amongst the provinces for both elective and non-elective waitlist and surgery counts. There was minimal change after March 2020 in the number of patients waiting for elective surgery in Nova Scotia, Newfoundland & Labrador, Ontario, and British Columbia. An increase in counts of patients on the wait list for elective surgery can be seen in New Brunswick, Quebec, Manitoba, and Alberta after the onset of the pandemic. (See Figure 6). There were no observed common trends among provinces for counts of elective surgeries performed.

Similar trends can be observed for non-elective surgery patient waitlists counts as the elective counts, Nova Scotia, Newfoundland & Labrador, Ontario, and British Columbia showed no notable changes after the start of the pandemic in March 2020. New Brunswick, Quebec, Manitoba, and Alberta all had a slight increase in non-elective waitlist patient counts. Quebec, Ontario, and Manitoba all show a decrease in non-elective surgeries performed directly after the onset of the pandemic, with only Quebec returning to pre-pandemic surgery counts. Fortunately, there was no major decreases in counts of non-elective surgeries being performed in the remainder of the provinces (See Figure 7).

DISCUSSION

This study aimed to identify the impact of the Covid-19 pandemic on the T2 and T3 wait times for elective spinal surgery and to quantify the number of patients waiting for elective and non-elective spinal surgery, along with the number of these surgeries being performed in Canada. In our national sample of patients who were waiting for spinal surgery, we found a significant increase in the national T2 and T3 wait times for both the ‘elective’ and ‘non-elective’ patient cohorts at the onset of the pandemic. In March 2020 and 6 months post-pandemic, the typical ‘elective’ patients were waiting longer than the recommended 182-day benchmark, ultimately returning to shorter waiting times (Figure 2). We also found an increase in the number of patients waiting nationally for both ‘elective’ and ‘non-elective’ spinal procedures and a decrease in the number of surgeries being performed in each cohort after the onset of the Covid-19 pandemic in March 2020 (Figure 3).

Although research is limited, our study found similar trends in the wait times for other elective surgical procedures in Canada affected by the Covid-19 pandemic. A study investigating the effects of the pandemic on elective cataract patients found a similar increase in the T2 wait times in the first year of the pandemic, but a net decrease in T2 times in the second year. [9] Contrarily, they found a decrease in patients on the waitlist for procedures, where we found an overall increase of people on the wait list for elective spinal surgeries.[9] Similarly to our findings, an Ontario study found that there was a decrease in the number of plastic and reconstructive surgeries being performed after the onset of the pandemic, as well as an overall increase in wait times for consultations and surgeries.[10]

Strengths & Limitations

Our study had various strengths and weaknesses which inform the interpretation of the study results. Through the CSORN data registry, we were able to include patients across Canada. This was one of the strengths of our study, the relatively large and geographically diverse patient and surgeon representation. This helps to improve the generalizability of our study. Although we had a large dataset, a limitation was some sites had few participating patients which forced some constraint on provincial specific analyses.

Our dataset did not include all patients nor surgeons in Canada, which may limit the generalizability of our findings. A random sample of Canadian elective spine surgery patients and surgeons may be more representative of the Canadian population.

Another strength of our study was the systematic fashion the data was collected for the registry intended for research purposes, allowing us to have prospectively collected data. Due to the nature of the data collection, there may be missing data, threatening the

internal validity of the study. Although there was missing data, all our data included the appropriate amount of the population we measured to support a proper analysis.

Research Implications

We have quantified the T2 & T3 waiting times for elective spinal patients in Canada with reference to the 'best practice' 182-day benchmark of elective orthopaedic procedures. Future research should investigate the effects of waiting on the outcomes experienced by patients undergoing spinal surgery. Preliminary research suggests that prolonged wait times, longer than 182 days, do have negative surgical outcome effects on disability, pain, and overall poor outcomes on patients undergoing anterior cervical discectomy, fusion for spondylotic radiculopathy, and surgery for degenerative lumbar spinal stenosis.[11,12] It is important to identify the effects of prolonged wait times on elective spinal surgery patient cohorts to not only reduce pain and suffering of patients but to inform clinicians and health policymakers for decision-making in the future.

CONCLUSION

The Covid-19 pandemic had a significant impact on national T2 and T3 wait times for elective spinal surgery patients, as well as the number of patients waiting for surgery and the number of surgical procedures performed. There appeared to be heterogeneous impacts of the Covid-19 pandemic between provinces for T2 and T3 wait times and the number of patients on the waitlist and surgical procedures performed. This information should be taken into consideration by clinicians and health policymakers when making decisions for each individual province in Canada. These findings can help inform future healthcare policies in the event of another wave of the Covid-19 pandemic or to decrease the backlog of elective spinal surgeries.

FIGURES

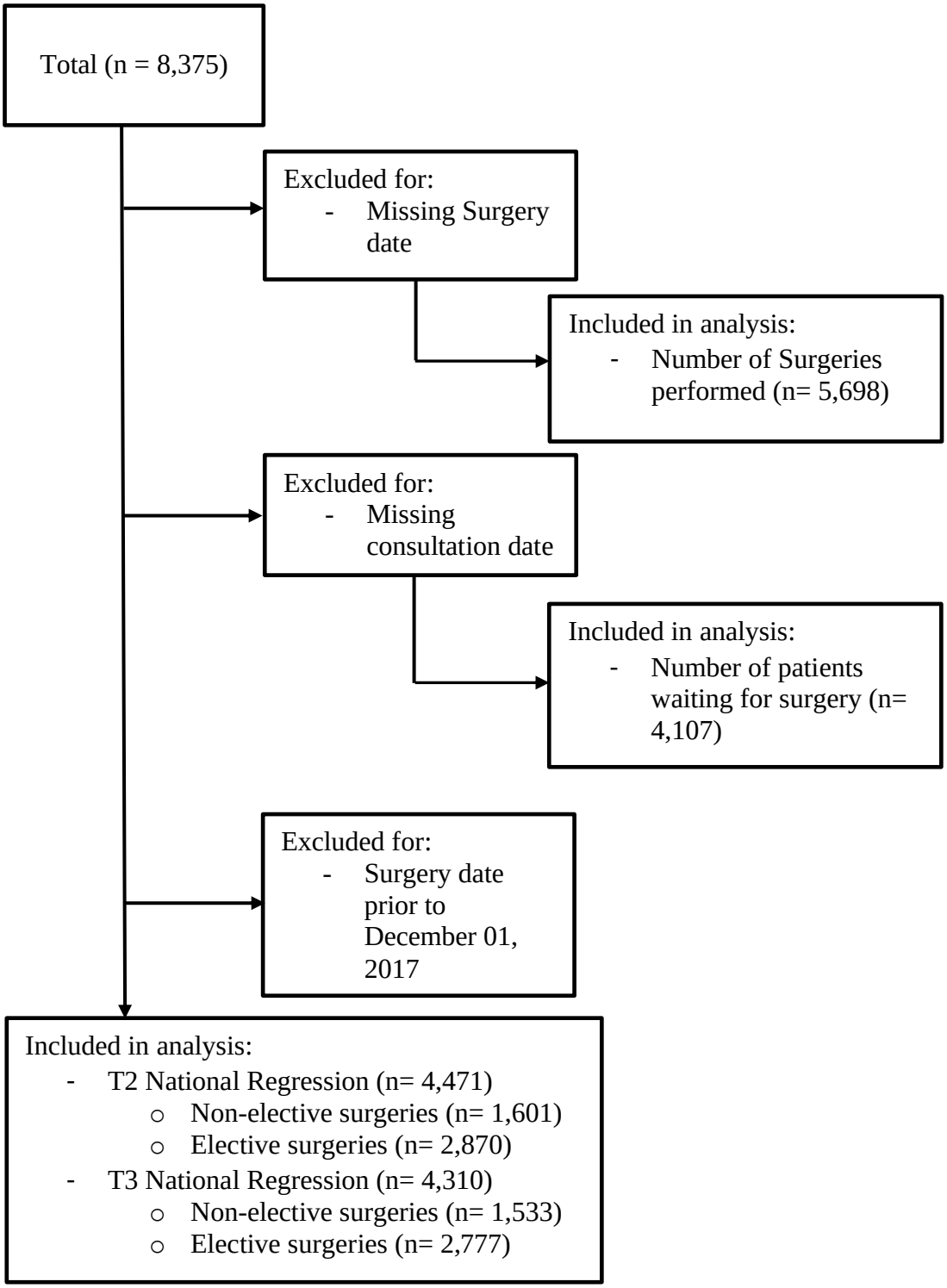


Figure 1. Study flow diagram

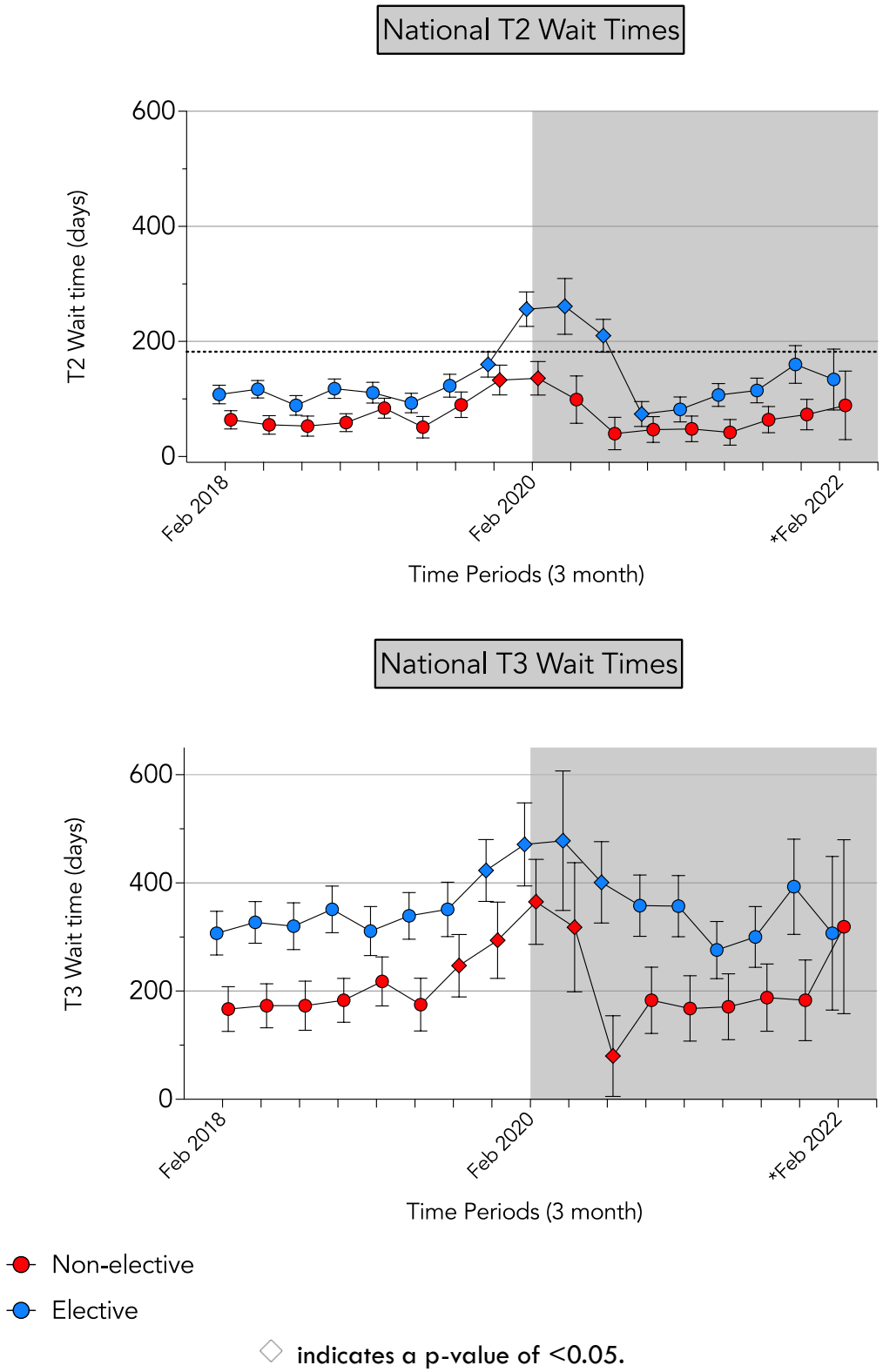
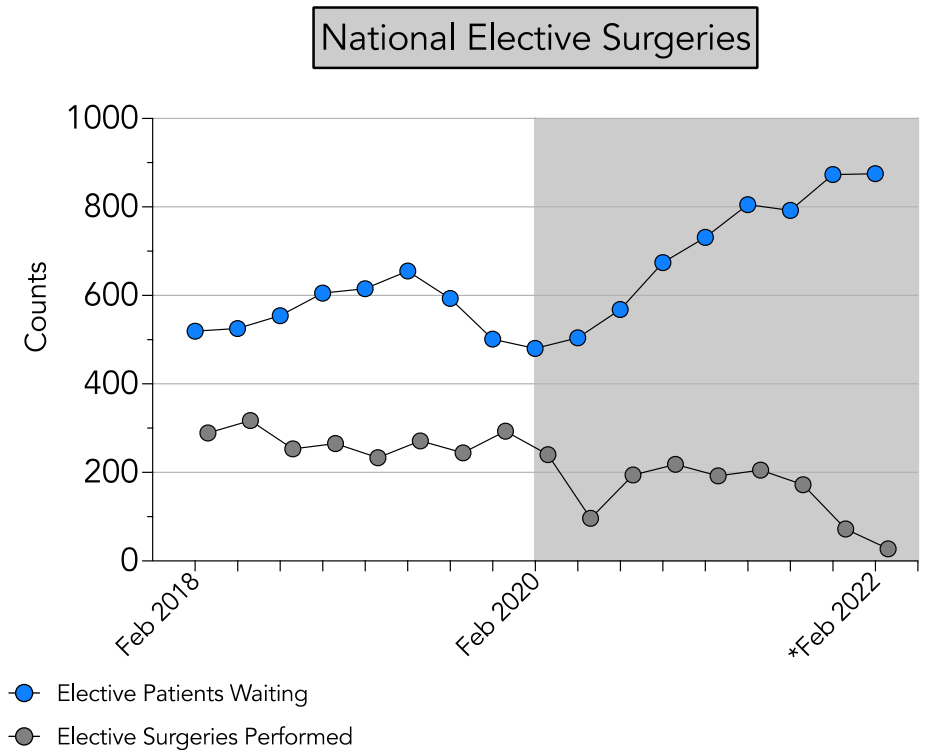


Figure 2. National T2 and T3 wait time regression models.



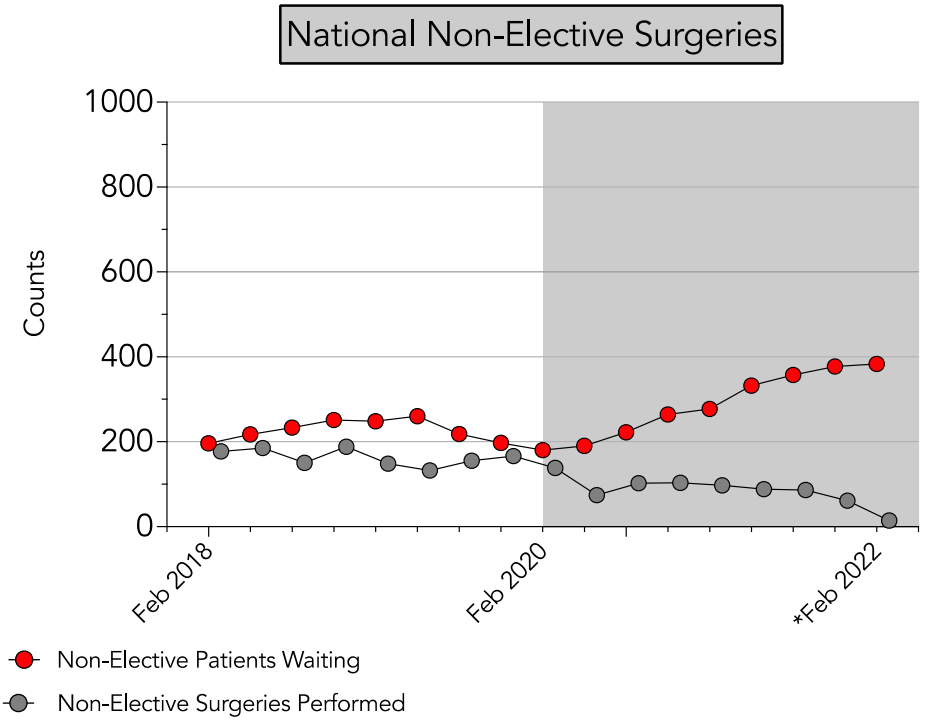


Figure 3. National counts of patients waiting for surgery and counts of surgeries performed.

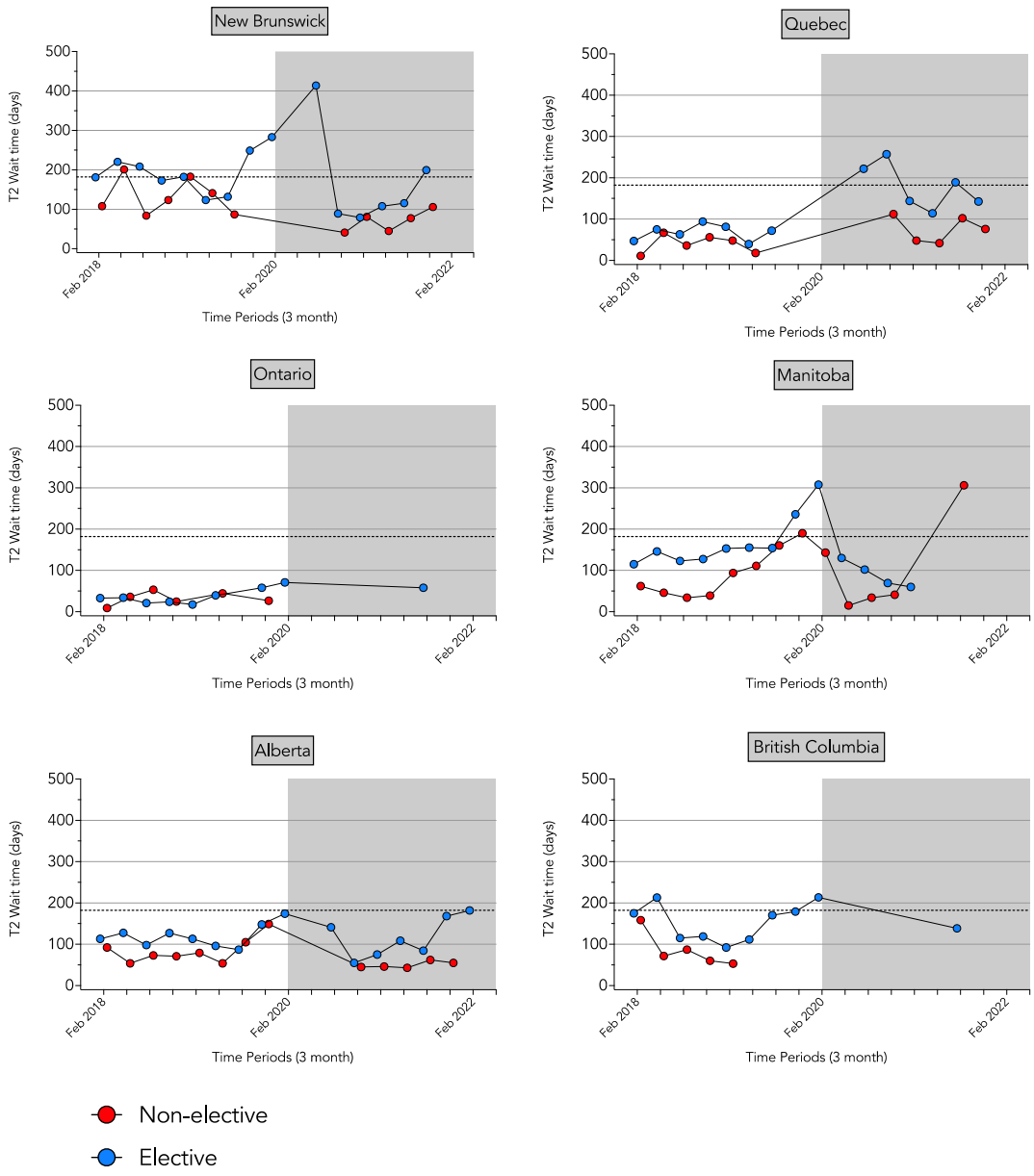


Figure 4. Provincial T2 median wait times.

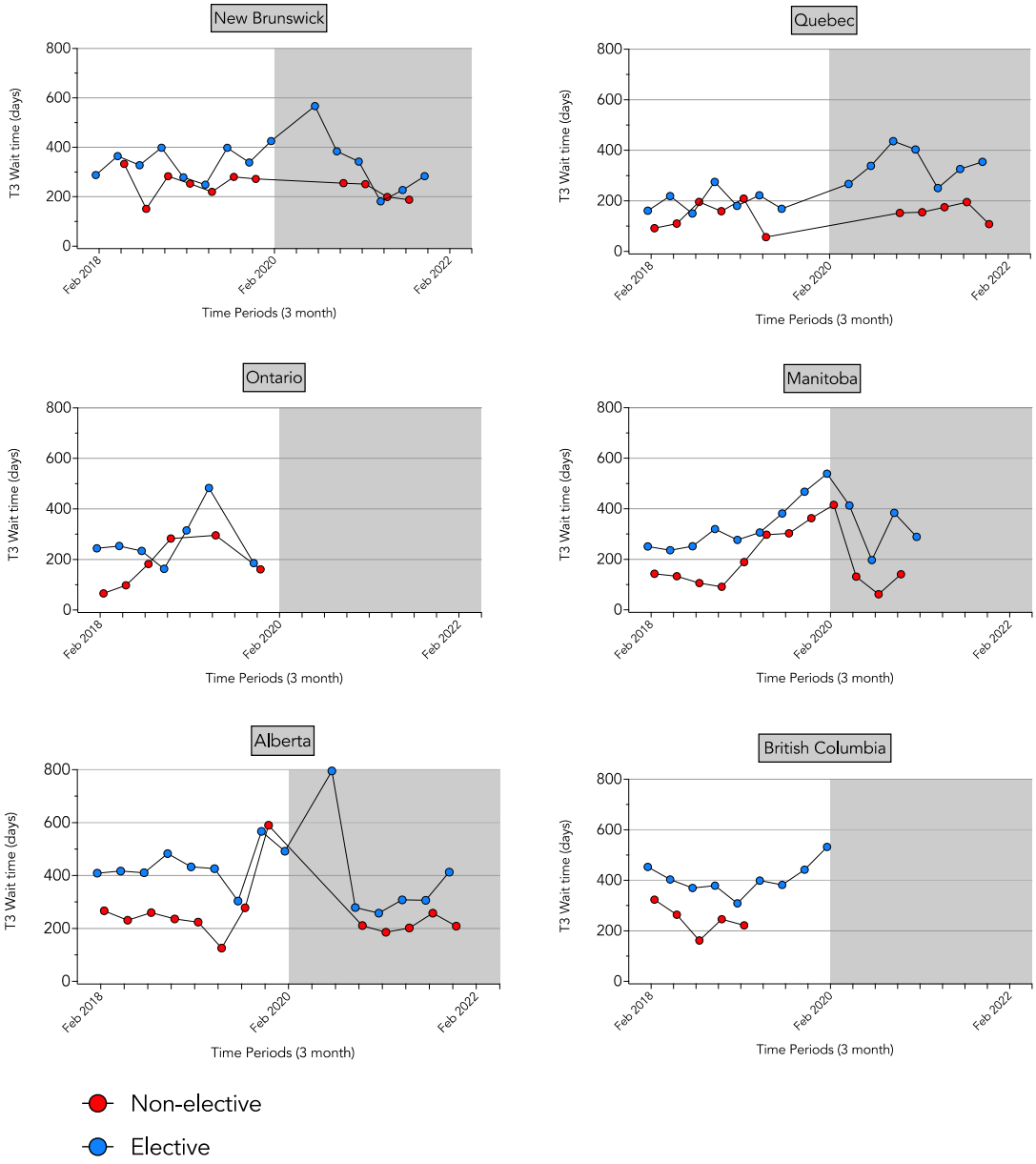


Figure 5. Provincial T3 median wait times.

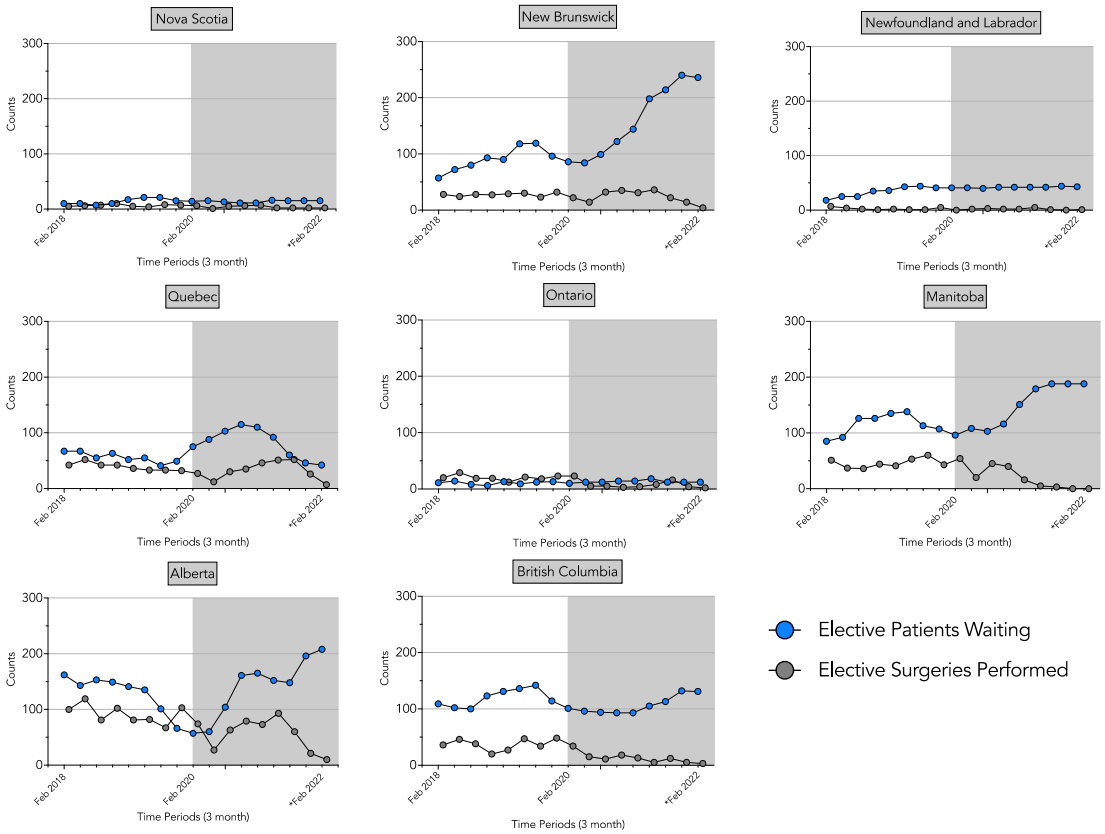


Figure 6. Elective counts of patients waiting for surgery and surgeries performed.

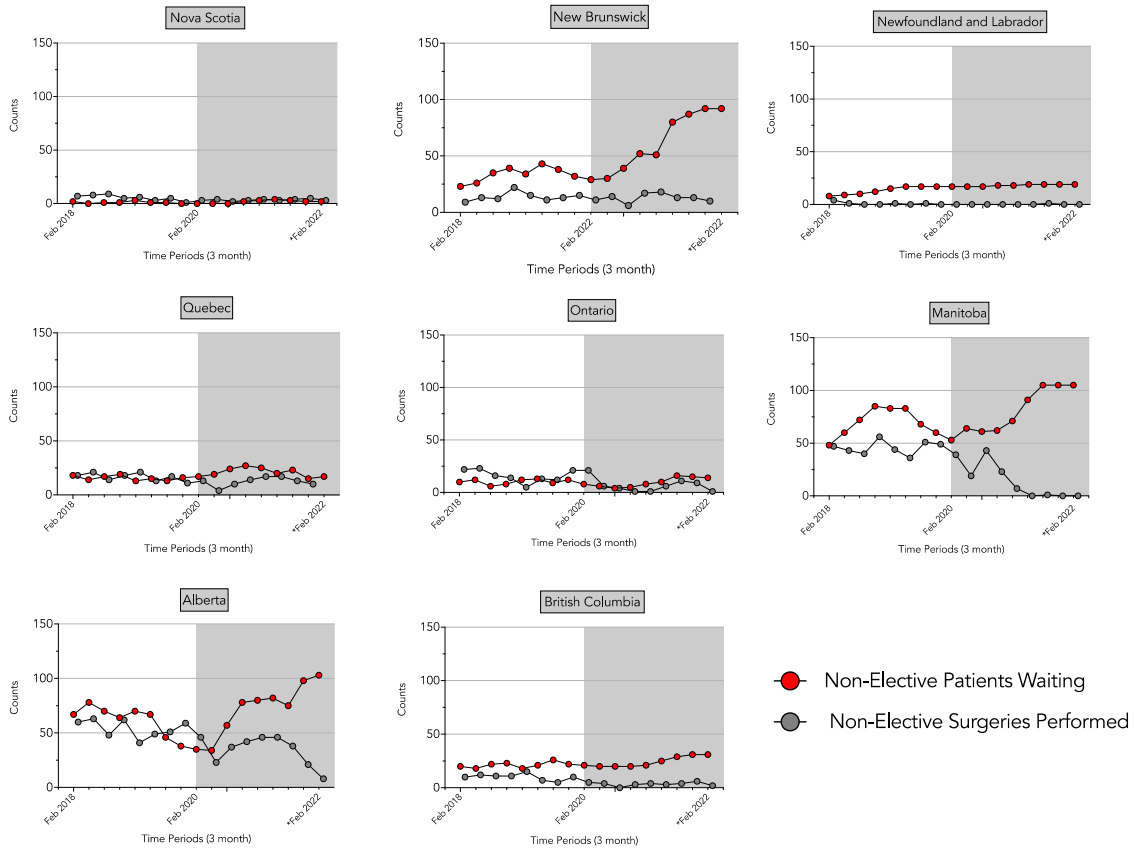


Figure 7. Non-elective counts of patients waiting for surgery and surgeries performed.

TABLES

Table 1. Spinal surgery patient characteristics and surgical details (N= 6,913).

Variables	**Elective (N= 4,429)**	**Non-elective (N=2,431)**
Age (years)	58.8 (14.6)	58.5 (13.5)
Female sex	2321 (52.4%)	1042 (42.9%)
Body mass index [kg/m^2]	29.2 (5.9)	29.0 (5.9)
Location of surgery		
Cervical	322 (7.3%)	1159 (47.7%)
Thoracolumbar	4106 (92.7%)	1268 (52.2%)
Surgery type		
Fusion	1491 (51.7%)	1038 (64.4%)
Non-fusion	1375 (47.7%)	562 (34.9%)
Pain intensity (NPRS)		
Axial	6.9 (2.2)	6.1 (2.8)
Limb	6.9 (2.5)	6.2 (2.9)
Pain-related disability		
NDI	45.3 (15.7)	41.0 (18.6)
ODI	46.4 (15.0)	48.9 (17.5)
Education Level		
Less than high school		
High school diploma	509 (11.8%)	300 (12.6%)
Technical School or Associates	1157 (26.8%)	675 (28.4%)
degree	813 (18.9%)	453 (19.1%)
University Degree	1366 (31.7%)	706 (29.8%)
Post-Graduate or Professional degree	466 (10.8%)	239 (10.1%)

Values indicated number (percent) or mean ±SD.
NDI= Neck Disability Index (0-100).
ODI= Oswestry Disability Index (0-100).
NPRS= Numeric pain rating scale (0-10).

APPENDIX A

Canadian Spine Outcomes and Research Network (CSORN)

CSORN is a multicentered national spine surgery registry that tracks and reports various spine surgeries, adverse events, and patient reported outcome measures from 23 orthopaedic and neurological surgical centers across the country. CSORN included data from more than 13,000 patients in 2021. The registry tracks surgical and non-surgical techniques used to treat spine conditions. This network is an effective tool used by surgeons and researchers to closely follow the prognosis of spinal conditions, identify patterns in treatments and recovery, track practice patterns and small area variation, assess treatment effectiveness, and manage resource utilization. CSORN collects both patient and physician reported outcomes. The goal of CSORN is to allow surgeons nationwide to participate in prospective multi-centered trials and retrospective analysis.

Table A. Quantile regression model for T2 ‘elective’ patient cohort.

T2_wait_time_2	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
study_period_3_mo						
1	9	11.36283	0.79	0.428	-13.2802	31.2802
2	-19	12.02719	-1.58	0.114	-42.58287	4.582868
3	10	11.91499	0.84	0.401	-13.36286	33.36286
4	3	12.31868	0.24	0.808	-21.15442	27.15442
5	-15	11.92712	-1.26	0.209	-38.38664	8.386645
6	15	13.04697	1.15	0.25	-10.58244	40.58244
7	52	13.95602	3.73	0	24.63508	79.36492
8	148	17.31891	8.55	0	114.0412	181.9588
9	153	26.10793	5.86	0	101.8077	204.1923
10	102	16.71294	6.1	0	69.22935	134.7707
11	-34	13.75194	-2.47	0.013	-60.96475	-7.03525
12	-26	13.78015	-1.89	0.059	-53.02007	1.020069
13	-1	13.0895	-0.08	0.939	-26.66585	24.66585
14	7	13.66909	0.51	0.609	-19.80229	33.80229
15	52	18.53793	2.81	0.005	15.6509	88.3491
16	26	28.2779	0.92	0.358	-29.44719	81.44719
_cons	108	8.242769	13.1	0	91.83761	124.1624

	Margin	Delta-method Std. Err.	z	P>z	[95% Conf.	Interval]

study_period_3_mo						
0	108	8.242769	13.1	0	91.84447	124.1555
1	117	7.821174	14.96	0	101.6708	132.3292
2	89	8.758431	10.16	0	71.83379	106.1662
3	118	8.603707	13.72	0	101.137	134.863
4	111	9.154597	12.13	0	93.05732	128.9427
5	93	8.620494	10.79	0	76.10414	109.8959
6	123	10.11336	12.16	0	103.1782	142.8218
7	160	11.26177	14.21	0	137.9273	182.0727
8	256	15.23159	16.81	0	226.1466	285.8534
9	261	24.77258	10.54	0	212.4466	309.5534
10	210	14.53888	14.44	0	181.5043	238.4957
11	74	11.00785	6.72	0	52.42502	95.57498
12	82	11.04307	7.43	0	60.35598	103.644
13	107	10.16818	10.52	0	87.07073	126.9293
14	115	10.90416	10.55	0	93.62824	136.3718
15	160	16.60457	9.64	0	127.4556	192.5444
16	134	27.04989	4.95	0	80.98319	187.0168

Table B. Quantile regression model for T2 ‘non-elective’ patient cohort.

T2_wait_time_2	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
study_period_3_mo						
1	-9	11.48932	-0.78	0.434	-31.53588	13.53588
2	-11	12.0252	-0.91	0.36	-34.58699	12.58699
3	-5	11.32729	-0.44	0.659	-27.21807	17.21807
4	20	12.04847	1.66	0.097	-3.632619	43.63262
5	-13	12.61352	-1.03	0.303	-37.74094	11.74094
6	26	13.95525	1.86	0.063	-1.372705	53.37271
7	69	15.45762	4.46	0	38.68045	99.31955

8	72	16.95007	4.25	0	38.75307	105.2469
9	35	22.54796	1.55	0.121	-9.226981	79.22698
10	-24	16.57677	-1.45	0.148	-56.51473	8.514726
11	-17	14.06449	-1.21	0.227	-44.58696	10.58696
12	-16	13.95525	-1.15	0.252	-43.37271	11.37271
13	-22	14.00933	-1.57	0.117	-49.47878	5.478783
14	0	14.17814	0	1	-27.8099	27.8099
15	9	15.73001	0.57	0.567	-21.85384	39.85384
16	25	31.42408	0.8	0.426	-36.63715	86.63715
_cons	64	8.136294	7.87	0	48.04096	79.95904

	Margin	Delta-method Std. Err.	z	P>z	[95% Conf.	Interval]
study_period_3_mo						
0	64	8.136294	7.87	0	48.05316	79.94684
1	55	8.112043	6.78	0	39.10069	70.89931
2	53	8.85473	5.99	0	35.64505	70.35495
3	59	7.880883	7.49	0	43.55375	74.44625
4	84	8.886297	9.45	0	66.58318	101.4168
5	51	9.638543	5.29	0	32.1088	69.8912
6	90	11.33798	7.94	0	67.77797	112.222
7	133	13.14301	10.12	0	107.2402	158.7598
8	136	14.86962	9.15	0	106.8561	165.1439
9	99	21.02882	4.71	0	57.78427	140.2157
10	40	14.44265	2.77	0.006	11.69292	68.30708
11	47	11.47216	4.1	0	24.51498	69.48502
12	48	11.33798	4.23	0	25.77797	70.22203
13	42	11.40448	3.68	0	19.64763	64.35237
14	64	11.61122	5.51	0	41.24242	86.75758
15	73	13.46232	5.42	0	46.61434	99.38566

16	89	30.35248	2.93	0.003	29.51022	148.4898

Table C. Quantile regression for T3 'elective' patient cohort.

T3_wait_time2	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
study_period_3_mo						
1	20	28.4967	0.7	0.483	-35.87702	75.87702
2	13	30.22105	0.43	0.667	-46.25816	72.25816
3	44	30.09274	1.46	0.144	-15.00657	103.0066
4	4	30.99635	0.13	0.897	-56.77838	64.77838
5	32	30.09274	1.06	0.288	-27.00657	91.00657
6	44	32.90741	1.34	0.181	-20.52563	108.5256
7	116	35.73882	3.25	0.001	45.92246	186.0775
8	164	44.23025	3.71	0	77.27227	250.7277
9	171	68.87758	2.48	0.013	35.94319	306.0568
10	94	43.59265	2.16	0.031	8.522496	179.4775
11	51	35.49149	1.44	0.151	-18.59257	120.5926
12	50	35.41094	1.41	0.158	-19.43461	119.4346
13	-31	33.97284	-0.91	0.362	-97.61475	35.61475
14	-7	35.3313	-0.2	0.843	-76.27845	62.27845
15	86	49.4064	1.74	0.082	-10.87725	182.8773
16	0	75.38499	0	1	-147.8167	147.8167
_cons	307	20.63382	14.88	0	266.5407	347.4593

	Margin	Delta-method Std. Err.	z	P>z	[95% Conf.	Interval]
study_period_3_mo						
0	307	20.63382	14.88	0	266.5585	347.4415
1	327	19.65471	16.64	0	288.4775	365.5225
2	320	22.08071	14.49	0	276.7226	363.2774
3	351	21.90476	16.02	0	308.0675	393.9325
4	311	23.13048	13.45	0	265.6651	356.3349
5	339	21.90476	15.48	0	296.0675	381.9325
6	351	25.6348	13.69	0	300.7567	401.2433
7	423	29.18063	14.5	0	365.807	480.193
8	471	39.12238	12.04	0	394.3215	547.6785
9	478	65.71428	7.27	0	349.2024	606.7976
10	401	38.40006	10.44	0	325.7373	476.2627
11	358	28.87718	12.4	0	301.4018	414.5982
12	357	28.77812	12.41	0	300.5959	413.4041
13	276	26.98887	10.23	0	223.1028	328.8972
14	300	28.68007	10.46	0	243.7881	356.2119
15	393	44.8914	8.75	0	305.0145	480.9855
16	307	72.50616	4.23	0	164.8905	449.1095

Table D. Quantile regression for T3 'non-elective' patient cohort.

T3_wait_time2	Coef.	Std. Err.	t	P>t	[95% Conf.	Interval]
study_period_3_mo						
1	6	29.58825	0.2	0.839	-52.03825	64.03825
2	6	31.34986	0.19	0.848	-55.49368	67.49368
3	16	29.46196	0.54	0.587	-41.79052	73.79052
4	51	31.22571	1.63	0.103	-10.25017	112.2502
5	8	32.62636	0.25	0.806	-55.99758	71.99758
6	80	36.2368	2.21	0.027	8.920426	151.0796
7	127	41.72013	3.04	0.002	45.16472	208.8353
8	198	45.28662	4.37	0	109.1689	286.8311
9	151	64.35241	2.35	0.019	24.77081	277.2292
10	-87	43.51131	-2	0.046	-172.3488	-1.65125
11	16	37.63183	0.43	0.671	-57.81597	89.81597
12	1	37.29879	0.03	0.979	-72.1627	74.1627
13	4	37.46352	0.11	0.915	-69.48582	77.48582
14	21	37.97972	0.55	0.58	-53.49835	95.49835
15	16	43.51131	0.37	0.713	-69.34875	101.3488
16	152	84.65892	1.8	0.073	-14.06101	318.061
_cons	167	21.04549	7.94	0	125.7186	208.2814

	Margin	Delta-method Std. Err.	z	P>z	[95% Conf.	Interval]
study_period_3_mo						
0	167	21.04549	7.94	0	125.7516	208.2484

1	173	20.79789	8.32	0	132.2369	213.7631
2	173	23.23577	7.45	0	127.4587	218.5413
3	183	20.61782	8.88	0	142.5898	223.4102
4	218	23.068	9.45	0	172.7876	263.2124
5	175	24.93124	7.02	0	126.1357	223.8643
6	247	29.49904	8.37	0	189.183	304.817
7	294	36.023	8.16	0	223.3962	364.6038
8	365	40.09945	9.1	0	286.4065	443.5935
9	318	60.81382	5.23	0	198.8071	437.1929
10	80	38.08309	2.1	0.036	5.358513	154.6415
11	183	31.19683	5.87	0	121.8553	244.1447
12	168	30.79427	5.46	0	107.6443	228.3557
13	171	30.99359	5.52	0	110.2537	231.7463
14	188	31.6156	5.95	0	126.0346	249.9654
15	183	38.08309	4.81	0	108.3585	257.6415
16	319	82.00134	3.89	0	158.2803	479.7197

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Curriculum Vitae

Candidate's full name: Taylor Alexandra Smith

Universities attended: University of New Brunswick, BScKin (Hon), 2022

Publications: N/A

Conference Presentations: N/A