

# Out-of-hours emergent surgery for degenerative spinal disease in Canada: a retrospective cohort study from a national registry



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## Summary

**Background** Spinal degenerative disease represents a growing burden on our healthcare system, yet little is known about longitudinal trends in access and care. Our goal was to provide an essential portrait of surgical volume trends for degenerative spinal pathologies within Canada.

**Methods** The *Canadian Institute for Health Information* (CIHI) database was used to identify all patients receiving surgery for a degenerative spinal condition from 2006 to 2019. Trends in number of interventions, unscheduled vs scheduled hospitalizations, in-hours vs out-of-hours interventions, resource utilization and adverse events were analyzed retrospectively using linear regression models. Confidence intervals were reported in the expected count ratio scale (CR).

**Findings** A total of 338,629 spinal interventions and 256,360 hospitalizations between 2006 and 2019 were analyzed. The mean and SD of the annual mean age of patients was 55.5 (SD 1.6) for elective hospitalizations and 55.6 (SD 1.6) for emergent hospitalizations. The proportion of female patients was 47.8% (91,789/192,027) for elective hospitalizations and 41.4% (26,633/64,333) for emergent hospitalizations. Elective hospitalizations increased an average of 2.0% per year, with CR = 1.020 (95% CI 1.017–1.023,  $p < 0.0001$ ) while emergent hospitalizations exhibited more rapid growth with an average 3.4% annually, with CR 1.034 (95% CI 1.027–1.040,  $p < 0.0001$ ). «In-hours» surgeries increased on average 2.7% per year, with CR 1.027 (95% CI 1.021–1.033,  $p < 0.0001$ ), while «out-of-hours» surgeries increased 6.1% annually, with CR 1.061 (95% CI 1.051–1.071,  $p < 0.0001$ ). The resource utilization for unscheduled hospitalizations approximates two and a half times that of scheduled hospitalizations. The proportions of spinal interventions with at least one adverse event increased on average 6.3% per year, with CR 1.063 (95% CI 1.049–1.077,  $p < 0.0001$ ).

**Interpretation** This study provides novel data critical for all providers and stakeholders. The rapid growth of emergent out-of-hours hospitalizations demonstrates that the needs of this growing patient population have far exceeded health-care resource allocations. Future studies will analyze the health-related quality of life implications of this system shift and identify demographic and socioeconomic inequities in access to surgical care.

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## Introduction

Spine degeneration is a normal process related to aging where both the mechanical properties and anatomic morphology are affected. Pathologies include stenosis, deformity, spondylolisthesis and disc herniation. Degenerative spinal disease represents one of the world's most common medical problems with a

prevalence of 27.3% in those aged sixty-five and above.<sup>1</sup> This disease is one of the biggest drivers of health care expenditures worldwide.<sup>2</sup> Current demographic patterns with population growth, especially of the elderly, suggest the prevalence of degenerative spine diagnoses will continue to increase around the world and thus put greater pressure on surgical resources.<sup>1</sup>

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### Research in context

#### Evidence before this study

We searched PubMed and Google Scholar for evidence regarding trends in surgical volume overtime for degenerative spinal disease. We also searched for trends overtime in emergency vs elective hospitalizations as well as in-hours vs out-of-hours surgery. We used the following search terms (“trends” OR “overtime”) AND (“surgical volume” OR “surgeries”) AND (“degenerative spinal disease”). Our search was limited to studies published before December 2022 without language restriction. We reviewed again the literature during the revisions stage. The lack of evidence regarding trends in surgical volume overtime in degenerative spinal disease was striking.

#### Added value of this study

While degenerative spinal pathologies are a growing burden on our healthcare system, little is known about national or regional variations in the surgical care of these diseases.

Fundamentally, demand currently outstrips capacity in our healthcare system with the gap growing year on year. The findings of this study present new and worrisome knowledge that is critical for all stakeholders navigating the changing spinal care environment of treating a growing elderly population with limited resources. The rapid growth of emergent out-of-hours hospitalizations demonstrates that the needs of this growing patient population have far exceeded health-care resource allocations.

#### Implications of all the available evidence

Our presented results are necessary to support evidence-based decisions in healthcare policy and future resource allocation. Our findings fill a critical knowledge gap. We must ensure equitable access to healthcare. This study provides benchmark numbers for future studies to identify inequities in surgical care which could then be targeted. Future studies could perform similar trend analysis in other surgical specialties.

The majority of degenerative pathologies present to the spinal surgeon in the outpatient clinic setting. However, some patients may present to the emergent department having deteriorated to the point that they require urgent interventions. Cauda equina syndrome and rapidly progressive myelopathy are examples of this phenomenon. Whenever possible, treating degenerative spinal pathologies electively during scheduled operating room time is preferable to performing such surgeries as emergencies in unscheduled “out-of-hours” operative time, as the latter has been associated with worse outcomes and higher rates of adverse events.<sup>3</sup> In addition, when otherwise elective surgeries are having to be done in unscheduled “out-of-hours” OR time, hospital resources are strained and not utilized efficiently.

The increased demands on surgical resources by the growing prevalence of degenerative spinal conditions is an issue requiring evaluation. Data to support evidence-based decisions in healthcare policy and future resource allocation is critical. Specifically, we must ensure equitable access to healthcare and minimize out-of-hours emergency presentation and treatment which is known to be harmful to patients. The main goal of this study was to provide an essential portrait of surgical volume trends for degenerative spinal pathologies within Canada. Secondly, we aimed to identify trends in scheduled vs unscheduled (emergent) hospitalizations, in-hours vs out-of-hours surgeries, resource utilization and adverse events.

## Methods

### Data source

This is a retrospective analysis of prospectively collected data obtained from a rigorously maintained national

registry, the *Canadian Institute for Health Information* (CIHI). The Strengthening the Reporting of Observational studies in Epidemiology (STROBE) guidelines were followed. The University of British Columbia Research ethics board approval was obtained. CIHI is an independent non-profit organization that prospectively collects comparable data across Canadian health systems. CIHI is a secondary data collector of health information under the authority of jurisdictional privacy and health information legislation and is subject to related data-sharing agreements. The national standard for morbidity data reporting is set via ICD-10-CA (the Canadian modification of ICD-10) and classification of health care procedures is done via the Canadian Classification of Health Interventions (CCI) developed by CIHI. CIHI also works closely with *Statistics Canada*.

### Patient sample

Patients who received surgical intervention for a degenerative spinal condition of the cervical, thoracic and lumbar spine from 2006 to 2019 were included. The years 2020 and 2021 were not analyzed given the significant impact of the COVID pandemic on all health-care systems operations. Patients were analyzed as a group (Canada) and stratified by province. The Yukon, Nunavut and Northwest territories were grouped in the CIHI database to reduce the likelihood of small cell suppression. With regards to Quebec data, as part of the agreement between the Government of Quebec and CIHI, the data transmitted by Quebec and held by CIHI was not available for this study.

The patient demographics information available via the CIHI database are: age, gender, urban/rural, quintiles for material deprivation index and quintiles for social deprivation index. The assigned values for

quintiles are from 1 for most privileged to 5 for most deprived. The CIHI database provided age as yearly means, medians, Q1 and Q3 for each study years. The spinal degenerative diagnostic categories included were based on the ICD-10-CA diagnoses codes used by CIHI. The diagnostic categories included were: 1) deforming dorsopathies (M40 to M43), 2) Spondylopathies (M45 to M49), 3) Other dorsopathies (M50 to M54) and 4) Multiple, if hospitalization had ICD-10-CA codes spanning multiple categories listed prior. The spinal procedures included were based on the CCI Intervention codes used by CIHI. The procedures included were: 1) release, spinal cord (1AW72 for spinal cord decompression), 2) repair spinal vertebrae (1SC80), 3) fixation, spinal vertebrae (1SC74), 3) fusion, spinal vertebrae (1SC75), 4) excision, spinal vertebrae (1SC89–1SC87), 5) implantation of internal device (1SE53), 6) repair, laminectomy, fusion and excision of atlas and axis (1SA80–1SA74–1SA75–1SA89), and 7) laminectomy of sacral (1SF80).

### Outcome measures

Data collected included: the number and proportions of scheduled and unscheduled hospitalizations per year, the total number of spinal interventions per year and the average number of spinal interventions per patient per year. Scheduled hospitalizations were predefined as: patients admitted for the scheduled treatment or admitted from another facility for an intervention that was scheduled. As the database is only able to provide elective (scheduled) vs emergent (unscheduled) status on hospitalizations, outpatient and day surgeries were not included. Unscheduled hospitalization was predefined as: patients admitted for serious or life/limb-threatening condition requiring immediate assessment and treatment, patients who had to be admitted earlier than scheduled because immediate treatment was required, and patients being transferred from another facility for immediate treatment. Unscheduled hospitalizations (urgent/emergent) included both new admissions and readmissions without distinction. The number of surgical interventions performed in-hours (predefined as between 0700 and 1600 on weekdays) and out-of-hours (predefined as evenings during week 1600–0700 and weekend Friday 1600 to Monday am 0700) per year was calculated. The definition of in-hours vs out-of-hours was predefined as a custom field before data extraction. The emergency-to-elective surgery ratio was calculated for each year.<sup>4</sup> The ratio was calculated by dividing the number of unscheduled hospitalizations by the number of scheduled hospitalizations.

The resource intensity weight (RIW) is calculated by CIHI for all hospitalizations using a blend of DAD data, ICD-10-CA/CCI and Case-Cost data, and analyzed via regression modelling. The RIW is an estimate of resource utilization for each unique patient hospitalization, when compared to the average of all Canadian

hospitalizations. A decimal number (or fraction) is calculated for each hospitalization. For example, an RIW of 1 indicates that the hospitalization in question utilized an average amount of resources; an RIW of 0.5 indicates that the hospitalization in question utilized half the average amount of resources; and an RIW of 2 indicates that the hospitalization utilized twice the average amount of resources.

CIHI records adverse events using ICD-10 codes Y40–Y84 (Y40–Y59: Drugs, medicaments and biological substances causing adverse effects in therapeutic use; Y60–Y69: Misadventures to patients during surgical and medical care; Y70–Y82: Medical devices associated with adverse incidents in diagnostic and therapeutic use; Y83–Y84: Surgical and other medical procedures as the cause of abnormal reaction of the patient, or of later complication, without mention of misadventure at the time of the procedure. The number and proportions of spinal interventions with at least one adverse event was collected using ICD-10 codes Y40–Y84.

### Statistical analysis

Descriptive statistics were used. Trends over time were tested via linear regression models of natural log-transformed counts (+1) and percentages vs year. Exponentiated regression coefficients are presented, which represent the multiplicative change per year (growth rates) in the dependent variables. Confidence intervals were reported in the expected count ratio scale (CR). Results were stratified by province and overall (Canada). Insufficient data in some provinces precluded their analysis in some models. Model fit was assessed via normal quantile–quantile (Q–Q) plots of the standardized residuals. All statistical analyses were performed using SAS version 9.4 (SAS Institute, Cary, NC).

## Results

### Patient population

This study analyzed a total of 256,360 hospitalizations and 338,629 spinal interventions for degenerative spinal disease from 2006 to 2019. The mean and SD of the annual mean age of patients was 55.5 (SD 1.6) years for elective hospitalizations and 55.6 (SD 1.6) for emergent hospitalizations. Every year, the median and IQR of patients ages are published for elective and emergent hospitalizations. To obtain sensible estimates of the total distribution over the study period, the median of the annual 25th centiles, the medians and 75th centiles yield an estimated overall median of 57.8 years (IQR 45.6–68.6) for elective and 57.0 (IQR 41.9–70.6) for emergent hospitalizations. The proportion of female patients was 47.8% (91,789/192,027) for elective hospitalizations and 41.4% (26,633/64,333) for emergent hospitalizations. The proportion of urban patients was 78.0% for elective hospitalizations (149,781/192,027) and 78.8% for emergent hospitalizations (50,694/

64,333). The proportion of patient corresponding to the most privileged quintile for material deprivation index was 19.8% (38,021/192,027) in the elective group and 19.5% (12,545/64,333) in the emergent group. The proportion of patients corresponding to the least privileged group in terms of material deprivation index was 15.5% (29,764/192,027) in the elective group and 20.6% (13,252/64,333) in the emergent group. The proportion of patient corresponding to the most privileged quintile for social deprivation index was 20.6% (39,557/192,027) in the elective group and 19.5% (12,545/64,333) in the emergent group. The proportion of patients corresponding to the least privileged group in terms of social deprivation was 18.7% (35,909/192,027) in the elective group and 21.9% (14,089/64,333) in the emergent group.

**Decompression only vs fusion spinal surgery**

The proportion of elective patients receiving decompression only surgery was 41.8% (107,374/256,876) and fusion surgery was 58.2% (149,501/256,876). The proportion of emergent patients receiving decompression only surgery was 44.1% (36,053/81,753) and fusion surgery was 55.9% (45,699/81,753). The number of decompression surgeries has not significantly changed over the study period ( $p = 0.093$ ) (Fig. 1). The number of fusion surgeries has increased on average 681 procedures per year (95% CI 636–724,  $p < 0.0001$ ). The proportion of fusion surgery for has been increasing 1.4% per year, with CR 1.014 (95% CI 1.010–1.017,  $p < 0.0001$ ).

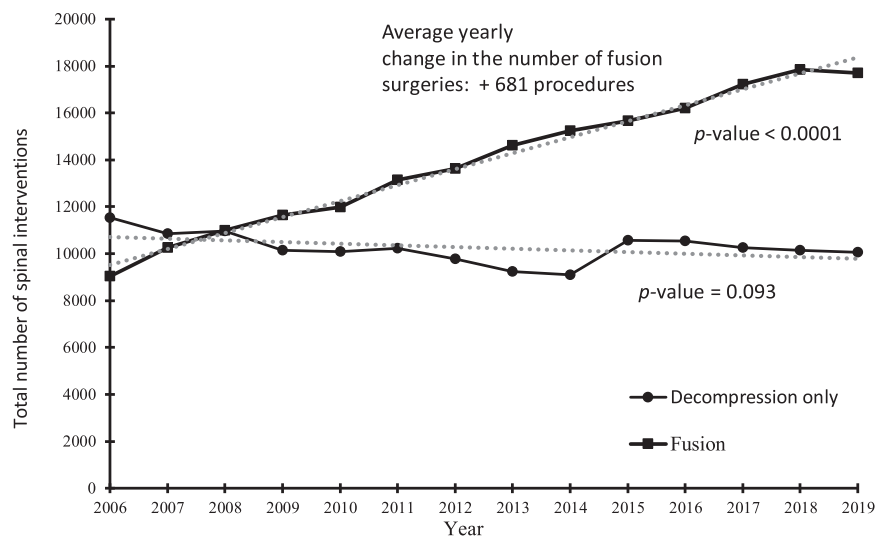
**Number of spinal interventions**

This study analyzed a total of 338,629 spinal interventions occurring in Canada from 2006 to 2019 (Table 1). The number of spinal interventions increased on average 2.5% per year, with CR 1.025 (95% CI 1.023–1.028,  $p < 0.0001$ ) (Fig. 2A). For reference, in 2006, 20,570 surgical interventions for degenerative spinal disease were performed in Canada compared to 27,748 interventions in 2019. The number of interventions significantly increased in each province individually (Fig. 2B).

The number of spinal interventions per patient has increased on average 0.03 additional intervention per patient per decade (95% CI 0.02–0.04,  $p < 0.0001$ ). In 2006, the national average was 1.32 spinal intervention per patient compared to 1.37 in 2019. This explains the higher number of surgical interventions compared to the number of hospitalizations. A significant increase in the number of spinal interventions per patient was observed for Alberta, British Columbia, Manitoba, Saskatchewan, New Brunswick and Nova Scotia. This increase was not observed in Ontario and Newfoundland.

**Scheduled vs unscheduled hospitalizations**

This study analyzed a total of 256,360 hospitalizations for degenerative spinal disease from 2006 to 2019. There were 192,027 elective hospitalizations (74.9%) and 64,333 emergent hospitalizations (25.1%). Nationally, the number of elective hospitalizations increased by an average of 2.0% per year, with CR 1.020 (95% CI 1.017–1.023,  $p < 0.0001$ ) (Fig. 3). The number of



**Fig. 1: Total number of decompression only vs fusion surgeries per year in Canada from 2006 to 2019.** Lined scatter plots demonstrating the total number of decompression only vs fusion surgery in Canada from 2006 to 2019. The grey, dashed lines illustrate respective trend lines. As described, the average yearly change in fusion surgery increased on average 681 procedures, while the average yearly change in decompression only surgery was not statistically significant.

Year	Total interventions	Total elective hospitalizations requiring spinal interventions	Total urgent hospitalizations requiring spinal interventions	Total urgent-to-elective hospitalization ratio	Average number of spinal interventions per patient	Emergent spinal interventions "in hours"	Emergent spinal interventions "out of hours"	Average RIW elective	Average RIW urgent	Number of spinal interventions with adverse events
2006	20,570	12,027	3751	0.31	1.33	NA	NA	1.93	5.29	2200
2007	21,107	12,272	3996	0.33	1.33	NA	NA	2.16	5.86	2279
2008	21,946	12,690	4151	0.33	1.33	NA	NA	2.03	5.34	2350
2009	21,802	12,660	4007	0.32	1.34	3537	1413	1.89	5.74	3015
2010	22,080	12,992	3839	0.30	1.34	3407	1410	1.98	6.15	3218
2011	23,371	13,488	4079	0.30	1.36	3577	1536	2.04	6.24	3567
2012	23,420	13,272	4350	0.33	1.36	3717	1583	2.12	5.98	3755
2013	23,870	13,400	4518	0.34	1.36	3878	1743	2.11	5.66	3718
2014	24,333	13,592	4684	0.34	1.36	3890	1836	2.00	5.50	4027
2015	26,213	14,526	5251	0.36	1.36	4200	2182	1.96	5.19	4595
2016	26,727	15,127	5061	0.33	1.36	3984	2086	1.89	5.22	4378
2017	27,486	15,243	5356	0.35	1.37	4176	2275	1.93	5.01	4549
2018	27,985	15,614	5568	0.36	1.36	4397	2280	1.92	5.01	4516
2019	27,748	15,124	5722	0.38	1.37	4530	2385	1.97	5.06	4564
<b>p-value</b>	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	0.220	0.033	<0.0001

NA, Not Available.

**Table 1:** Yearly Canadian average and surgical trends in degenerative spinal disease from 2006 to 2019.

emergent hospitalizations increased at a faster pace of 3.4% per year, with CR 1.034 (95% CI 1.027–1.040,  $p < 0.0001$ ). In all provinces, the number of elective hospitalizations also increased. The number of emergent hospitalizations significantly increased in Alberta, Manitoba, Newfoundland, Nova Scotia and Ontario. The Urgent-to-elective hospitalization ratio increased from 0.31 in 2006 to 0.38 in 2019 ( $p < 0.0001$ ) (Table 1).

#### In-hours vs out-of-hours surgical interventions

Surgical interventions performed «in-hours» increased on average 2.7% per year, with CR 1.027 (95% CI 1.021–1.033,  $p < 0.0001$ ), while surgical interventions performed «out-of-hours» had a more rapid growth of 6.1% per year, with CR 1.061 (95% CI 1.051–1.071,  $p < 0.0001$ ) (Fig. 4). A similar trend of a greater increase in out-of-hours operations than in-hours operations was observed in Alberta, British Columbia, Newfoundland, Ontario and Saskatchewan.

#### Resource utilization per hospitalization

The average resource utilization (intensity weight, RIW) for scheduled hospitalization has not significantly changed over time from 1.93 in 2006 to 1.97 in 2019 ( $p = 0.22$ ) (Fig. 5A). In other words, the resource utilization for an elective hospitalization for spinal surgery has remained a little less than twice the national average for all surgical specialties combined. The average resource utilization for an unscheduled spinal hospitalization was 5.39 in 2006 and 5.06 in 2019 ( $p = 0.033$ ) (Fig. 5B). In other words, the resource utilization for an unscheduled hospitalization for spinal surgery has

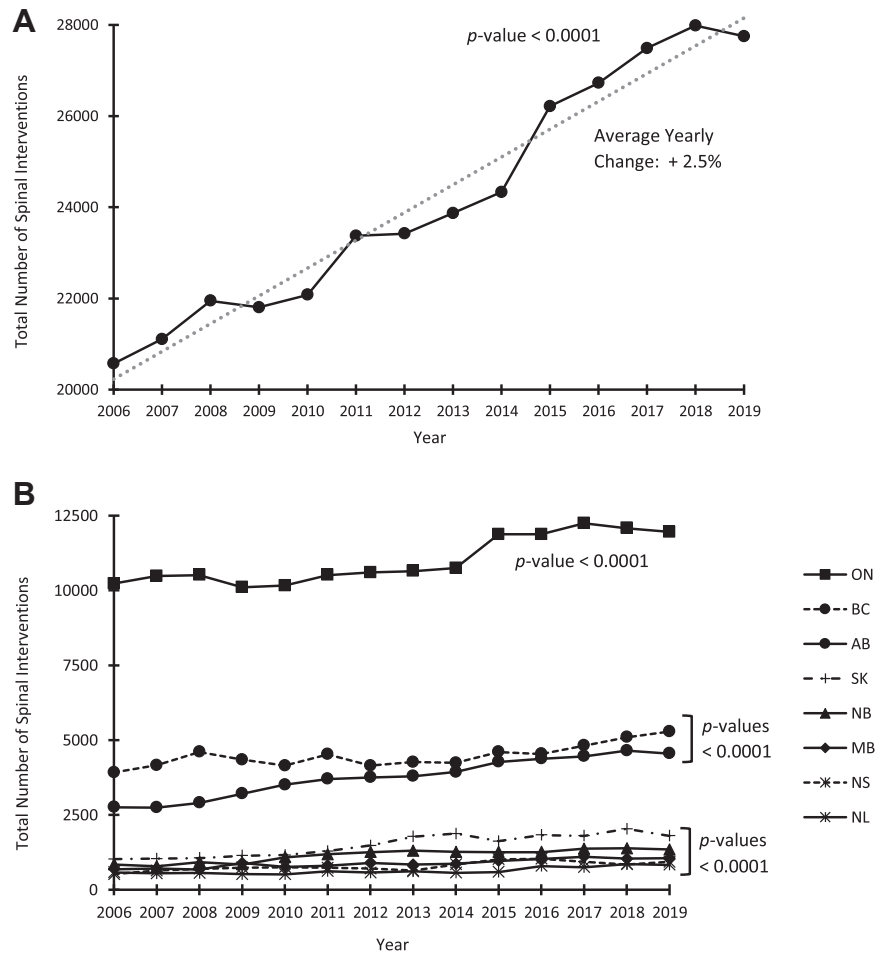
remained more than 2.5 times the resource utilization for an elective hospitalization for spinal surgery for degenerative spinal disease and more than five times the national average for all surgical specialties combined.

#### Adverse events

The overall proportion of spinal interventions with at least one adverse event increased on average 6.3% per year, with CR 1.063 (95% CI 1.049–1.077,  $p < 0.0001$ ) (Fig. 6). A significant increase was observed in Alberta, British Columbia, Manitoba, Newfoundland, Nova Scotia, Ontario and Saskatchewan with New Brunswick showing a trend. The proportion of elective spinal interventions with at least one adverse event was 18.2% (46,751/256,876) compared to 30.1% (19,364/64,333) for emergent spinal interventions ( $p < 0.0001$ ).

#### Discussion

This study presents novel data that is critical for all Canadian and international stakeholders navigating the changing spinal care environment of a growing elderly population. This study presents fourteen years of data on 338,629 spinal interventions and 256,360 hospitalizations, taking a rigorous look at surgical trends for degenerative spinal disease. Our two main findings are the faster growth in emergent surgical procedures compared to elective procedures and the faster growth rate of out-of-hours spinal surgical procedures compared to in-hours operations. As need outpaces the capacity of the elective surgical system, patients present to the emergency department in a decompensated state

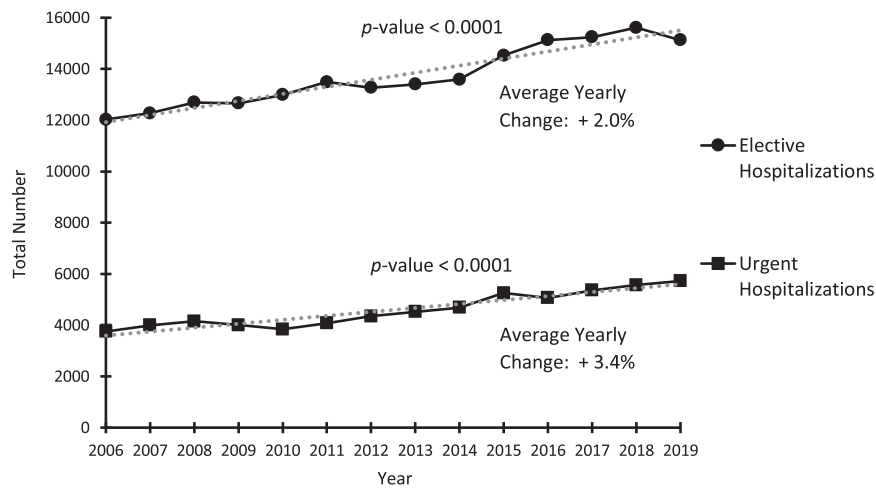


**Fig. 2: Total number of spinal interventions per year in Canada and per province from 2006 to 2019.** Lined scatter plots demonstrating the total number of spinal interventions in (A) Canada and (B) in each province from 2006 to 2019. All plots are significant with  $p$ -values  $< 0.0001$ , as indicated. The grey, dashed line in (a) illustrates the trend line, with average yearly increase in spinal interventions of 2.5%, as described. ON, Ontario; BC, British Columbia; AB, Alberta; SK, Saskatchewan; NB, New Brunswick; MB, Manitoba; NS, Nova Scotia; NL, Newfoundland and Labrador.

and require emergency and out-of-hours surgery with a higher utilization of resources compared to scheduled hospitalizations. Our study also identified an increase in adverse events over time, which may be related to an increasing proportion of emergency surgeries performed on clinically decompensated patients.

The more rapid growth in unscheduled out-of-hours hospitalizations may be related to a concerning acute clinical deterioration either before referral or after referral, but before consultation with a spinal surgeon or while waiting for surgery. The financial and clinical impacts of treating patients emergently who could have been treated in a scheduled fashion has not been well assessed in spinal surgery. However, unscheduled and out-of hours surgery has been widely associated with worse outcomes.<sup>3,5-7</sup> Our findings also show a higher rate of adverse events for emergent hospitalizations vs

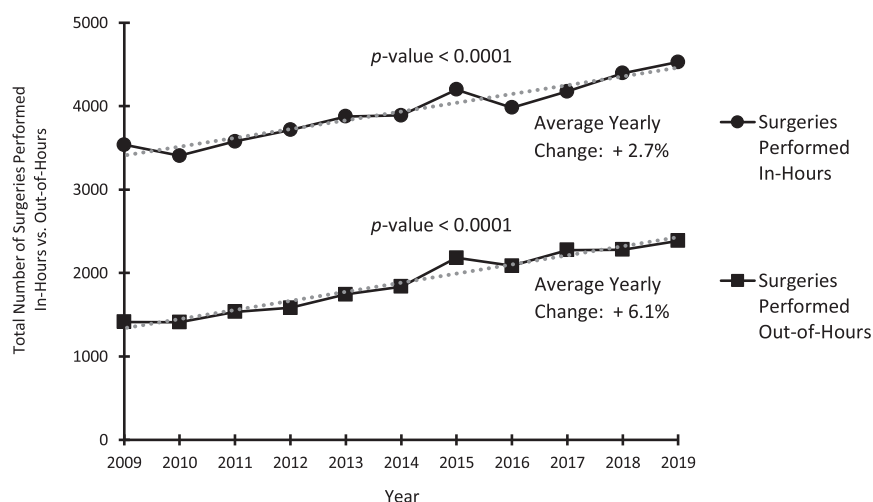
elective hospitalizations. Patients presenting emergently with neurological decompensation may be irreversible with morbidity having long term costs, which could have been avoided with better access to resources. A cost-effectiveness analysis balancing quality adjusted life years and costs in spinal surgery should be performed to compare increasing resources for scheduled or elective surgeries vs the cost of performing an increasing number of emergency surgeries. Over the study period, the resource utilization overtime for scheduled surgery has not significantly changed, but it has slightly improved for emergent surgeries (5.39 in 2006 and 5.06 in 2019,  $p = 0.03$ ). It is possible that, nationally, our efficiency in resource allocation for emergency surgery is improving in face of this increasing burden. However, our study showed that the cost of an unscheduled hospitalization remains five times higher than the national



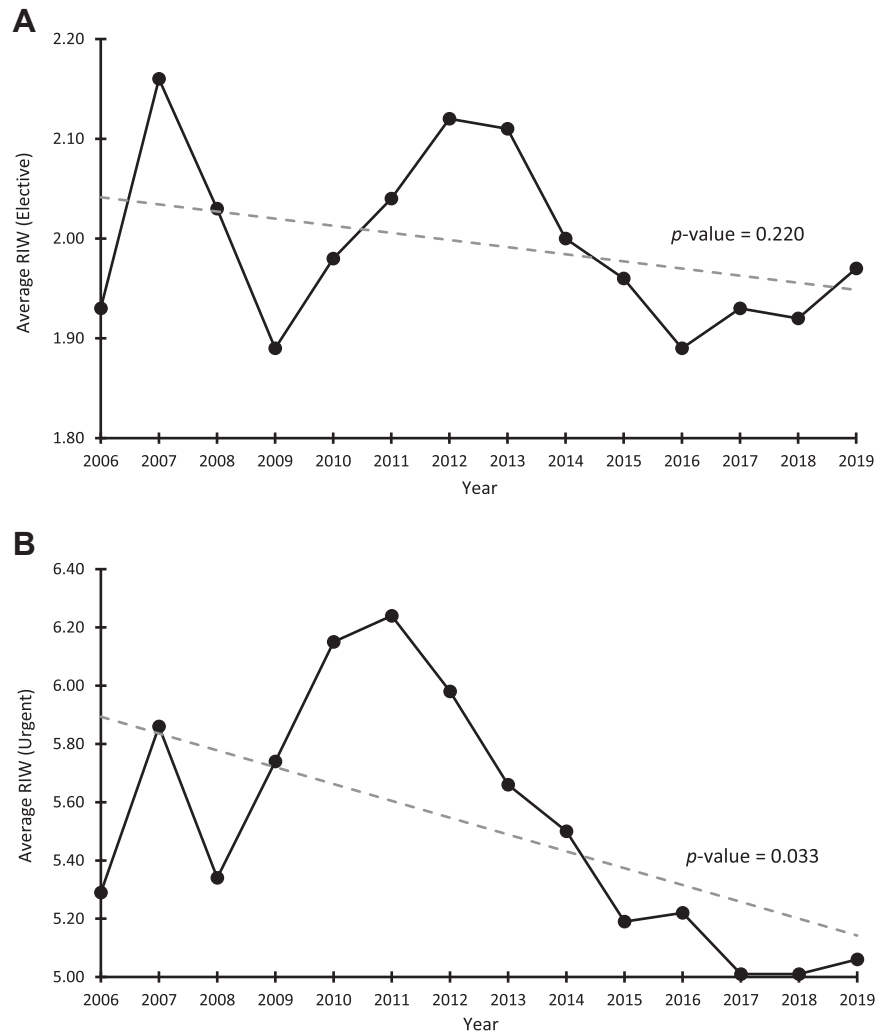
**Fig. 3: Total number of elective and urgent hospitalizations requiring spinal interventions within Canada from 2006 to 2019.** Lined scatter plots demonstrating the total number of elective and urgent hospitalizations requiring spinal interventions in Canada from 2006 to 2019. Both plots are significant with p-values <0.0001, as indicated. The grey, dashed lines illustrate respective trend lines. As described, the average yearly change in elective hospitalizations increased at a rate of 2.0%, while the average yearly change in urgent hospitalizations increased at a faster rate of 3.4%.

average for all specialties combined and over two and a half times higher than a scheduled hospitalization. In other surgical specialties, it has been shown that performing surgeries electively rather than emergently are associated with significant cost saving. In a study of half a million patients done to determine costs in surgery for AAA repair, coronary artery bypass graft and colon resection, if a modest 10% of the weighted estimated of

emergency procedures would have been performed electively, the cost benefit would have been nearly 1 billion dollars.<sup>8</sup> A similar cost saving may be possible by increasing resources for scheduled surgery for degenerative spinal disease. The role of training more surgeons with spinal expertise may also become an increasingly important and vital part for future planning. For example, in Japan, Kobayashi et al. showed



**Fig. 4: Total number of spinal surgeries performed in-hours versus out-of-hours in Canada from 2009 to 2019.** Lined scatter plots demonstrating the total number of spinal surgeries performed in-hours versus out-of-hours in Canada from 2009 to 2019. All plots are significant with p-values <0.0001, as indicated. The grey, dashed lines illustrate respective trend lines. As described, the average yearly change in spinal surgeries performed in-hours increased a rate of 2.7%, while the average yearly change in spinal surgeries performed out-of-hours increased at a faster rate of 6.1%.



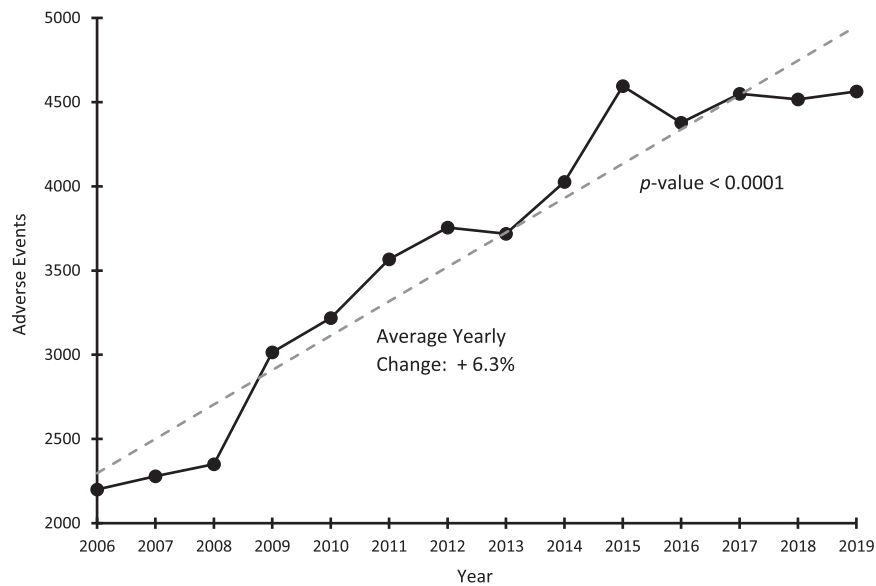
**Fig. 5: Average resource intensity weights for elective and urgent spinal hospitalizations in Canada from 2006 to 2019.** Lined scatter plots demonstrating the average resource intensity weights (RIW) in Canada for (A) elective and (B) urgent spinal hospitalizations from 2006 to 2019. The plots have p-values of 0.220 and 0.033 as indicated, respectively. The grey, dashed lines in both plots illustrate the trend lines.

that a discrepancy exists between a 2.4 times increase in the number of surgeries performed vs a 1.5 times increase in the number of surgeons.<sup>9</sup>

The observed increase in surgical demand of 2.5% per year is likely due to the increasing elderly population and, potentially, an increase in the number of spine surgeons. It may also be related to changes in indications for spinal surgery. An increased demand for degenerative spinal surgery has also been shown in other countries. A study from Japan showed a particularly marked increase in the annual number of spinal surgeries for spinal degenerative disease by 2.6 times over 15 years.<sup>9</sup> In Norway, the surgical rate (surgery per 100,000 inhabitants) has significantly increased from 1999 to 2013 and among those aged 75 years and above, the rate of surgery increased by more than a factor of

five during that same period.<sup>10</sup> The 2.5% yearly growth is more rapid than the average Canadian population growth rate from 2006 to 2019 of 1.1%.<sup>11</sup> From 2016 to 2021, the number of Canadians aged 65 and older increased 18.3%, approximately 3.7% per year, which explains the increasing demand.<sup>12</sup> Similarly, the demand for surgery for degenerative disease of the hip and knee has been rising dramatically.<sup>13,14</sup> But, to our knowledge, similar trend analysis to this study is not available in other surgical specialties. Surgeries for total hip and knee arthroplasty have been widely accepted as cost-effective and resources have been mobilized to accommodate the increasing demand.<sup>15</sup> Despite studies showing that the cost-effectiveness and improvement in quality of life are similar between degenerative lumbar surgery and hip and knee surgery, spine surgeries





**Fig. 6: Total number of spinal interventions with adverse events in Canada from 2006 to 2019.** Lined scatter plot demonstrating the total number of spinal interventions with adverse events in Canada from 2006 to 2019. The plot is significant with  $p$ -value  $< 0.0001$ , as indicated. The grey, dashed line illustrates the trend line. The average yearly increase in adverse events is 6.3%, as described.

remain underfunded.<sup>13,15–17</sup> Moreover, unlike degenerative arthritis of the hip and knee, patients waiting for spinal surgery do measurably deteriorate with new or worsening neurological deficits with potentially permanent impairment and require emergency surgery. Mahon et al. showed that the length of wait for elective total hip arthroplasty was not associated with post-operative health related quality of life and mobility.<sup>18</sup> In contrast, a longer wait time for spine surgery was associated with worse outcomes and worse functional status.<sup>19,20</sup>

The present study also showed an increasing proportion of hospitalizations associated with an adverse event. Similarly, In Norway, Grotle et al. found an increase in mean complication rate over a 15-year period.<sup>10</sup> This worrisome increase is most likely related to the increase in emergency surgeries being performed and the growing elderly population receiving complex spinal surgical care. Notably, our study showed a higher rate of adverse event in the emergent population compared to the elective population. There are available reports showing that the rate of lumbar surgery for patients above 65 years old increased significantly over the past decades.<sup>9,21,22</sup> Additionally, the association between age and adverse events has been widely reported in the literature.<sup>23–29</sup> Future studies should assess trends surgical care based on demographics such as age, gender, rural vs metropolitan living and socioeconomic status. This study provides benchmark numbers for future studies to identify inequities in surgical care which could then be targeted.

A strength of this analysis resides in the large volume of data including all spinal surgery procedures for degenerative spinal disease carried out in public hospitals in Canada (except Quebec) during a 14-year period. A general limitation of registries is that not all details can be collected or analyzed. The risk of misclassification of diagnoses or procedures is also possible. However, this risk is reduced with a very large sample size and systematic data collection sourced from CIHI, an independent institute which collects comparable data across all Canadian healthcare systems following a national standard. The difference in the number of spinal interventions and hospitalizations can be explained by some patients receiving more than one spinal intervention per hospitalization. For example, on average, in 2019, a patient received 1.37 spinal intervention. There are very few published studies that provide an overview of all types of degenerative spinal surgeries and none published from Canada. Prior studies only focused on smaller groups or specific spinal pathology. The inclusion of data from a diverse range of clinical institutions and surgeons increases the generalization of presented results. This study presents national level data, which was provided to the authors by the Canadian Institute for Health Information. Future studies could perform similar trend analysis in other surgical specialties.

### Conclusion

This study presents new and compelling benchmark data that is critical for all stakeholders navigating the changing spinal care environment of a worldwide

growing elderly population. We report a faster growth rate in emergent out-of-hours procedures comparing to elective in hours operations with higher resource utilization and more adverse events. As the need outstrips the capacity, patients present to emergency department in a decompensated state and require emergency and out-of-hours surgery. With this new benchmark data, future studies should analyze if inequities exist in access to surgical care in different patient demographics.

#### Contributors

Charlotte Dandurand: Conceptualization, data curation, formal analysis, methodology, visualisation, writing—original draft.

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#### Data sharing statement

Due to participant confidentiality and ethical considerations, individual-level data cannot be made publicly available. To obtain access to the data, a request has to be made to CIHI (Canadian Institute for Health Information).

#### Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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