Regional Variation in Time to Surgery for Hip Fracture Patients in Canada

by

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Dedication Page

This thesis is dedicated to my mother, Elizabeth Ann Sutherland, and my father, Richard James Filliter. All my success in life is due to their endless love, support, and guidance.

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Abstract

Variation in time to hip fracture surgery has been observed across provinces. This variation may represent inequity in access to care and an underuse of early surgery. Differences between provinces in patient and system characteristics may contribute to provincial variation in time to surgery. However, the extent to which these characteristics influence the observed variation is unknown. The objective of this study is to compare time to surgery across provinces among surgically fit patients and their subgroups defined by timing of admission and type of surgery, respectively.

We use data from the Canadian Institute for Health Information's Discharge Abstract Database to examine 140,235 patients, 65 years or older, who were treated surgically for hip fracture between 2004 and 2012 in Canada, excluding Quebec. We estimate the proportion of surgeries completed on admission day and within three inpatient days, and the number of inpatient days required to complete 33%, 66%, and 90% of surgeries across provinces and among subgroups of patients defined by timing of admission and type of surgery, respectively. Provincial differences in time to surgery are adjusted for patient and system characteristics.

No province met the national time to surgery benchmark by completing 90% of surgeries within three inpatient days. Provinces completed a similar proportion of surgeries within the benchmark, and all provinces required four inpatient days to complete 90% of surgeries. However, variation was observed across provinces in the proportion of patients treated on admission day and the number of inpatient days required to complete 33% and 66% of surgeries overall, by timing of admission, and by type of surgery.

These findings may be indicative of differences in how hip fracture surgery is prioritized at various decision making levels and the efforts of provinces to work within their existing health care structures to implement processes to treat patients within the recommended time.

List of Abbreviations Used

CIHI	Canadian Institute for Health Information
DAD	Discharge Abstract Database
NACRS	National Ambulatory Care Reporting System
CCHF	Canadian Collaborative Study of Hip Fractures
OR	Operating Room
ED	Emergency Department
OECD	Organization for Economic Co-operation and Development
NICE	National Institute for Health and Care Excellence
CCI	Canadian Classification of Health Interventions
CCP	Canadian Classification of Procedures
GATE	Graphic Appraisal Tool for Epidemiologic studies

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This thesis contributes to and is part of a broader research collaborative entitled the Canadian Collaborative Study of Hip Fractures. The Canadian Collaborative Study of Hip Fractures aims to determine the effect of surgical delays on health outcomes following hip fracture in Canada. Part of this thesis has been published as an article entitled “Time to surgery after hip fracture across Canada by timing of admission” in *Osteoporosis International* for the Canadian Collaborative Study of Hip Fractures. The article includes the overall results and the results of the timing of admission subgroup analyses. These results are presented here in Chapter five and six. This thesis also includes and expands upon the justification for the study, the methods, and the discussion of the results presented in the published article. In addition, this thesis presents two novel subgroup analyses based on type of surgery. These results are presented in Chapter six.

Chapter 1: Introduction

Population health is the study of health outcomes and the patterns of health determinants in a group of individuals (1). Hip fracture is defined as a break in the area between the edge of the femoral head and five centimetres below the lesser trochanter (2). The aetiology of hip fracture is complex with many characteristics contributing to the risk of fracture. Biomechanical characteristics (falls, physical inactivity, muscle weakness, body anthropometrics, and bone structure), clinical characteristics (chronic health conditions, impaired cognition, impaired vision, and use of medication, alcohol, or chemical substances), and environmental characteristics all may contribute to the risk of fracture (3). Consequently, hip fracture primarily affects older adults. The number of hip fractures in Canada has been steadily increasing since 1985 and is expected to continue to increase due to population ageing (4). For those over the age of 40 years, the annual rate of hip fracture is 147.9 fractures per 100,000 persons, higher than the reported rates for breast, lung, or prostate cancer (5). This translates to more than 25,000 admissions to hospital for hip fracture and reflects a substantial population health burden (6,7). Even with treatment, one out of every ten hip fracture patients die within a month of the injury and one out of every three patients die within a year (8). Among surviving patients, 25% fail to recover function and 22% transition from independent living to long-term care facilities (9-11).

Public health is defined as the collective action of society to create conditions that allow individuals to be healthy (12). To reduce pain and restore mobility, between 94 and 98% of patients are treated surgically (13,14). Hip fracture surgery is an urgent procedure

and is generally given a priority classification indicating that surgery be performed within 48 hours of admission. In Canada, surgery is primarily performed in large community hospitals or teaching hospitals with advanced standards of surgery and highly specialized staff (7). The surgical procedures used to treat hip fracture can be broadly categorized as internal fixation, hemiarthroplasty, and total hip arthroplasty. Internal fixation may be used to treat transcervical fractures, intertrochanteric fractures, or subtrochanteric fractures, while total hip arthroplasty and hemiarthroplasty are only used to treat transcervical fractures (15,16). The provision of these surgical services is a major undertaking of the Canadian public health care system.

Many experts believe that early hip fracture surgery improves the rate of survival (17). After sustaining a hip fracture, patients are bleeding, they are in pain, and they are immobile, confined to bed rest. These characteristics introduce inflammatory, hypercoagulable, catabolic, and stress states that may lead to medical complications. Longer delays may reduce the therapeutic effects of surgery, as patients are exposed to these harmful states for longer periods of time (18). In 2005, Canadian First Ministers established a time to surgery benchmark of 48 hours from the time of admission for 90% of patients to reduce the potential detrimental effects of treatment delays (19,20).

Time to hip fracture surgery in Canada has been reported in annual waiting time reports published by the Canadian Institute for Health Information (CIHI) and in scientific journals. The data used to report time to surgery primarily comes from the CIHI's Discharge Abstract Database (DAD) and the CIHI's National Ambulatory Care

Reporting System (NACRS) (21,22). Using this data, researchers have described time to surgery in Manitoba, Ontario, and Quebec in scientific publications (23-26). In addition, the CIHI has released annual waiting time reports describing time to surgery across provinces in Canada. These reports include two distinct projects: the CIHI's Health Indicators reports (2007–2013) and the CIHI's Wait Times for Priority Procedures (2010–present) (20,27-40). Reports from the literature indicate that time to surgery varies across provinces in Canada.

Since the establishment of the time to hip fracture surgery benchmark, provincial variation in time to surgery has persisted, and to this day, most provinces are not meeting the benchmark (20,27-40). Indeed, whether the benchmark has had a uniform effect across provinces is unknown. The Canada Health Act guarantees uniform access to care (41). However, provinces are responsible for the organization and delivery of health care services. Provincial health care systems differ in terms of administration, funding, and delivery of services (42,43). It is therefore conceivable that the benchmark has had a differential effect across provinces.

It is unclear if the observed provincial variation in time to hip fracture surgery reflects inequity in access to care and an underuse of early surgery. Differences between provinces in patient characteristics may contribute to the variation in time to surgery. Patients who present to hospital in poor health may be appropriately delayed to surgery for preoperative tests and procedures (44-46). These delays are medically necessary, as the risk of perioperative complications may increase if a patient is not properly stabilized

(46). Patients may also be delayed for nonmedical reasons. Access to resources may differ across provinces due to differences in the structure of the health care systems delivering the health care services and in the processes employed in delivering the services. To what extent these characteristics contribute to the observed provincial variation in time to surgery is unclear. For instance, it is unknown if the variation across provinces would persist among surgically fit patients. Comparing time to surgery across provinces among surgically fit patients can provide insight into whether the observed variation reflects an unmet need.

Variation in the practice of scheduling patients for surgery across hospitals may contribute to the provincial variation in time to hip fracture surgery (47). While hospitals have limited ability to determine the timing of urgent procedures, hip fracture surgery may be underprioritized in the scheduling process due to limited resources (48). Two characteristics associated with the availability of resources are the timing admission and type of surgery. The availability of resources, such as ORs and surgical staff, may vary across provinces by timing of admission and type of surgery. For instance, some hospitals reduce the capacity of ORs after-hours and over the weekend (49,50). In addition, total hip arthroplasty is a complex procedure that requires additional resources such as a surgeon with arthroplasty experience (51,52). Comparing time to surgery across provinces among subgroups of patients defined by timing of admission or type of surgery can provide insight into whether the observed variation reflects an unmet need among patients with different admission times or types of surgery.

The aim of this study is to determine if early surgery is being underused in the Canadian provinces and to provide insight into the extent to which patient and system characteristics contribute to the observed provincial variation in time to hip fracture surgery. More specifically, the objective of this study is to determine if the provincial variation in time to surgery represents an underuse of early surgery by estimating and comparing time to surgery across provinces among surgically fit patients and their subgroups of patients defined by timing of admission and type of surgery, respectively. The results may be useful to health care administrators and provincial public health officials who are responsible for developing and implementing processes to ensure the timely and equitable treatment of hip fracture patients across Canada.

This thesis is organized into ten chapters. The chapters are as follows: introduction, literature review, objectives, methodology, overall results, subgroup analyses results, discussion, strengths and limitations, future research, and conclusion. Chapter one introduces hip fracture as population health issue and the delivery of hip fracture surgery as a public health issue. It provides an overview of previous literature on time to hip fracture surgery, articulates the justification for the study, and presents the broad study objectives. Chapter two provides an in-depth review of the literature on the outcomes and treatment of hip fracture, time to surgery (definition, measurement, available data, previous reporting, associated characteristics, and importance of early surgery), and provincial variation in time to surgery (measurement, reporting, implications, and associated characteristics). It finishes by highlight the gaps in the literature. Chapter three reiterates the justification for the study, presents the study

questions, highlights the contribution to the literature, introduces and justifies the methods used to answer the study questions, and formally states the objectives. Chapter four provides a detailed account of the methods used to meet the objectives. It describes the study design, data source, study population, outcomes, study variable, covariates, subgroup analyses, and the statistical analyses. Chapter five presents the overall results. Chapter six presents the results of the subgroup analyses. Chapter seven highlights the main findings and contextualizes the results within the existing body of evidence. Chapter eight presents the strengths and limitations of the study. Chapter nine presents future directions for research. Chapter ten reviews the justification for the study, the study questions, and summarizes the findings, while highlighting their implication for public health.

This thesis contributes to and is part of a broader research collaborative entitled the Canadian Collaborative Study of Hip Fractures (CCHF) (53). The CCHF aims to determine the effect of surgical delays on health outcomes following hip fracture in Canada. Part of this thesis has been published as an article entitled "Time to surgery after hip fracture across Canada by timing of admission" in *Osteoporosis International* for the CCHF (47). The article includes the overall results and the results of the timing of admission subgroup analyses. These results are presented here in Chapter five and six. This thesis also includes and expands upon the justification for the study, the methods, and the discussion of the results presented in the published article. In addition, this thesis presents two novel subgroup analyses based on type of surgery. These results are presented in Chapter six.

Chapter 2: Literature Review

The following chapter provides a detailed review of the literature to give the reader a thorough understanding of the importance of investigating whether hip fracture surgery is provided in a timely and equitable fashion across provinces in Canada. The chapter begins by describing the outcomes of hip fracture, highlighting the gravity of the injury, and how and where hip fracture patients are treated in Canada. It reviews the literature on how time to surgery is defined and measured, what data is used to estimate time to surgery, and it summarizes estimates of time to surgery in Canada and around the world. The chapter reviews the recommendations from clinical guidelines on time to surgery, identifies patient and system characteristics associated with delay to surgery, highlights the importance of early surgery, and details the establishment of the Canadian time to surgery benchmark. The chapter reviews the measurement, previous reporting, importance and implications, and associated characteristics of provincial variation in time to surgery. The chapter finishes by identifying the gaps in the literature.

Section 2.1: Outcomes

Hip fractures affects 25,000 older Canadians each year with serious and severe outcomes. Even with treatment, one out of every ten patients die within a month of the injury and one out of every three patients die within a year (8). Medical complications occur frequently in hip fracture patients, with as many as 20% of patients sustaining a postoperative complication (54). Complications may include chest infection, cardiac failure, deep vein thrombosis, deep infection, urinary tract infection, gastrointestinal

hemorrhage, myocardial infarction, and stroke (54). Among surviving patients, 25% fail to recover function and 22% transition from independent living to long-term care facilities (9-11). The consequences of the injury also have profound effects on the health care system and society.

The direct and indirect financial impact of hip fractures is substantial. In Canada, the mean direct attributable cost of care in the first year following fracture has been estimated to be between $35,000 and $40,000 (11). This translates to approximately $1.1 billion in annual health care costs (11). In addition, the Canadian economy suffers from the indirect costs of hip fracture, including lost wages from the patient's caregivers (55). Clearly, hip fracture is a devastating injury that has serious and severe consequences for patients and a massive impact on the Canadian health care system and society. Substantial resources are mobilized each year to treat hip fracture patients with the best quality of care.

Section 2.2: Treatment

To reduce pain and restore mobility, between 94 and 98% of patients are treated surgically (13,14). When perioperative risks are too high for surgery to be performed, patients are treated nonsurgically (less than 6% of all patients) (13,14,56). Surgical treatment of hip fractures can be broadly categorized as internal fixation, hemiarthroplasty, and total hip arthroplasty. Internal fixation may be used to treat transcervical fractures, intertrochanteric fractures, or subtrochanteric fractures, while total hip arthroplasty and hemiarthroplasty are only used to treat transcervical fractures

(15,16). In general, internal fixation involves fixing the fracture with nails, screws, and plates, and hip arthroplasty (hemiarthroplasty or total hip arthroplasty) involves repairing the fracture by replacing either part of or the full hip joint (16).

Surgical procedures vary in complexity and demand for resources. The surgical procedure is selected by the surgeon and is based on the characteristics of the fracture, the characteristics of the patient, and their surgical experience (57). The least invasive surgical procedure is internal fixation. It has the shortest operation time and benefits from reduced cost of materials (52). Total hip arthroplasty is the most complex and demanding procedure (52). The procedure requires longer operation times, has greater initial costs, and requires additional resources, such as a surgeon with total hip arthroplasty experience (52,58). Clinical guidelines recommend that internal fixation be used to treat patients with an intertrochanteric, subtrochanteric, and undisplaced transcervical fractures. Hip arthroplasty (total hip arthroplasty or hemiarthroplasty) is recommended for patients with a displaced transcervical fracture, as these procedures are associated with lower complication rates, improved functional outcomes, and reduced pain (52,59,60). Clinical guidelines also recommend that total hip arthroplasty be offered to patients with a displaced transcervical fracture who could walk independently with no more than a stick, are surgically fit, and are not cognitively impaired (59). For these patients, total hip arthroplasty is recommended over hemiarthroplasty, as it has been associated with improved functional outcomes and reduced pain (58,60). However, total hip arthroplasty is a complex procedure, and many surgeons will not perform the procedure unless it is

part of their routine elective practice (51). The provision of these surgical services is a major undertaking of the Canadian public health care system.

Developing and organizing a health care system with the ability to deliver surgical services requires an enormous amount of resources, time, and planning. Such a system requires the coordinated effort of individuals working in governance, service delivery, human resources, medicines and technologies, information, and financing (61). Provision of these services are vital in prolonging life and preventing disability (62). In Canada, hip fracture surgery is primarily performed in teaching hospitals or large community hospitals (7). Teaching hospitals are hospitals that belong to the Association of Canadian Academic Healthcare Organizations, and large community hospitals are hospitals with a capacity of more than 200 beds (63). Teaching hospitals are associated with advanced standards of surgery and highly specialized staff (24,64). Hospitals with different bed capacities have different approaches to delivering health care services and varying levels of stand-by capacity and hospital resources (65). Some small and medium community hospitals do not have the resources necessary to perform surgery or care for more complex patients who present with multiple comorbidities (66). For instance, these hospitals may not have an orthopaedic surgeon, anesthesiologist, or the necessary operating room (OR) equipment, instruments, or implants. Rather than investing in the necessary resources, these hospitals may choose to develop and organize a transfer process. As a result, some patients are transferred to larger community hospitals or teaching hospitals to receive surgery (29). However, whether a patient is treated in a teaching hospital or a smaller community hospital, the provision of timely surgery is

vital. Consequently, researchers and organizations have devoted substantial resources to defining, measuring, and reporting time to hip fracture surgery.

Section 2.3: Defining and measuring time to hip fracture surgery

Time to hip fracture surgery may be defined in different ways. Waiting time denotes the time between two events: the time one enters a queue and the time one exits a queue (67). Depending on the purpose of the study, these two events may be defined differently. Generally in Canada, time to hip fracture surgery has been defined as the time between admission and surgery (20,27-40). However, several distinct events take place between the time when a patient sustains a hip fracture and when they receive surgery. These include registration at the emergency department (ED), initial assessment at the ED, and admission to hospital (25). As a result, time to surgery may be defined differently by employing different events to denote when a patient enters the queue. Once time to surgery has been defined, a decision must be made on how to measure time to surgery.

Time to hip fracture surgery may be measured in different ways. In the analysis of waiting time data, the access function is frequently used to describe time to surgery. The access function presents the proportion of patients treated as a function of time. Presented graphically, the function allows for the easy discernment of two informative summary measures: the proportion of patients who were treated by a certain time and the amount of time required to treat a certain proportion of patients. The mean waiting time may also be

used as a summary measure (68). Once a decision has been made on how to measure time to surgery, a data source must be identified to estimate time to surgery.

Section 2.4: Canadian waiting time data

The data available for studying time to hip fracture surgery in Canada comes from several sources. The primary source is the CIHI's DAD. The dataset includes discharge abstracts for all acute care hospitalizations in the country, excluding Quebec. It includes administrative, demographic, and clinical information (21). The discharge abstracts from Quebec are compiled separately by the CIHI and are available in the Hospital Morbidity Database (21). However, the data elements available in the DAD are different from the Quebec data elements available in the Hospital Morbidity Database (69). As a result, time to surgery in Quebec is often studied separately from the rest of Canada (70). Data from the CIHI's NACRS may be used to study waiting time in the ED. This dataset contains information on hospital-based and community-based ambulatory care, including day surgery, outpatient and community clinics, and EDs (22). After selecting a definition and measurement of time to surgery and identifying a data source, time to surgery may be estimated.

Section 2.5: Time to hip fracture surgery in Canada and around the world

Time to hip fracture surgery in the Canadian provinces has been estimated with different definitions and measures of time to surgery. In 2000, Ho, Hamilton, and Roos defined time to surgery from admission and measured the mean time to surgery. They found that the mean time to surgery was 3.3 days in Manitoba and 3.1 days in Quebec

(23). In 2005, Weller et al. studied time to surgery in Ontario. They defined time to surgery from admission and measured the proportion of patients treated on admission day, inpatient day two, inpatient day three, and the proportion of patients treated from inpatient day four to eight. They found that 35% of patients underwent surgery on admission day, 44% on inpatient day two, 13% on inpatient day three, and 8% underwent surgery from inpatient day four to eight (24). In 2010, Frood and Tracey defined time to surgery as both the time from admission and the time from registration at the ED. Studying patients surgically treated in Ontario, they measured the proportion of patients treated within 48 hours as well as the number of hours required to complete 50% and 90% of surgeries. When they defined time to surgery from admission, they found that 78% of patients were treated within 48 hours, 26 hours were required to complete 50% of surgeries, and 74 hours were required to complete 90% of surgeries. When they defined time to surgery from registration at the ED, they found that 71% of patients were treated within 48 hours, 32 hours were required to complete 50% of surgeries, and 81 hours were required to complete 90% of surgeries (25). In 2018, Pincus et al. defined time to surgery as both the time from admission and the time from registration at the ED. They measured the mean time to surgery in Ontario, and they found that the mean time to surgery was 31.18 hours from admission and 38.76 hours from registration at the ED (26). In addition to the reporting of time to surgery in scientific journals, the CIHI has published annual waiting time reports that estimate time to surgery across provinces in Canada.

The CIHI has reported extensively on time to hip fracture surgery in Canada, employing different measures. The CIHI's Health Indicators reports defined time to

surgery as the time from admission, and they measured the proportion of patients treated within two and three inpatient days (2007–2010) and the proportion of patients treated within 48 hours (2011–2013) (20,35-40). In 2010, the CIHI reported that 62.7% and 84.2% of patients were treated within two and three inpatient days, respectively (38). In 2013, the CIHI reported that 81.1% of patients were treated within 48 hours (35). The CIHI's Wait Times for Priority Procedures reporting (2010–present) defined time to surgery as the time from admission and measured the proportion of patients treated within 48 hours and the number of hours required to complete 50% and 90% of surgeries (27-34). In 2017, the CIHI reported that 86% of patients underwent surgery within 48 hours, 23 hours were required to complete 50% of surgeries, and 55 hours were required to complete 90% of surgeries (27). A substantial effort has been devoted to reporting time to surgery in Canada and similar efforts have been undertaken by many countries around the world.

Internationally, time to hip fracture surgery has been measured in different ways. To promote consistent reporting, the Organization for Economic Co-operation and Development (OECD) established the Health Care Quality Indicators Project in 2001. Since 2007, the OECD has released a report approximately every two years that details time to surgery indicators for hip fracture (71-75). In a report published in 2017, Norway, Denmark, the Netherlands, Switzerland, Israel, Germany, Belgium, Austria, New Zealand, Finland, Estonia, Ireland, the Czech Republic, Lithuania, Slovenia, Italy, Spain, Portugal, Latvia, and Costa Rica reported time to surgery to the OECD as the proportion of patients treated on admission day, on inpatient day two, and on inpatient

day three. Sweden reported time to surgery as the proportion of patients treated within 12, 24, and 48 hours, and Hungary reported time to surgery as the proportion of patients treated within two inpatient days (71). In England, Wales, and Northern Ireland, the Royal College of Physicians reported time to surgery as the proportion of patients treated within two inpatient days (13). In 2017, the OECD reported that more than 90% of surgeries were completed within three inpatient days in Denmark, Iceland, and the Netherlands; in Norway, the United Kingdom, Finland, and New Zealand between 80% and 90% of surgeries were completed within three inpatient days; and in Italy, Portugal, and Spain less than 80% of patients were completed within three inpatient days (71). Time to surgery may vary across countries internationally and across provinces within Canada due to a variety of patient and system characteristics that are known to be associated with time to surgery.

Section 2.6: Characteristics that affect time to hip fracture surgery

Delay to hip fracture surgery is multifactorial. Characteristics known to affect time to hip fracture surgery can be categorized as patient and system characteristics. Patient characteristics include age, anticoagulant/antiplatelet therapy, clinical stability, sex, socioeconomic status, comorbidity, race, and out-of-hours admission. System characteristics include medical testing, prioritisation, surgery type, preoperative transfer, insurance status, hospital type (teaching hospital or small, medium, or large community hospital defined by bed capacity), hospital volume, and hospital region. The mechanisms by which patient and system characteristics affect time to surgery include out-of-hours admission, prioritization, resource availability, and surgical readiness (76).

Figure 1 presents the mechanisms by which patient and system characteristics affect time to hip fracture surgery. The characteristics and the proposed mechanisms were identified in the literature by Sheehan et al. in a scoping review published in 2017 (76). The patient and system characteristics are listed in the left column, mediators are listed in the middle column, and time to surgery, the outcome of interest, is listed in the right column. Arrows represent the proposed relationships between patient and system characteristics, mediators, and the outcome.

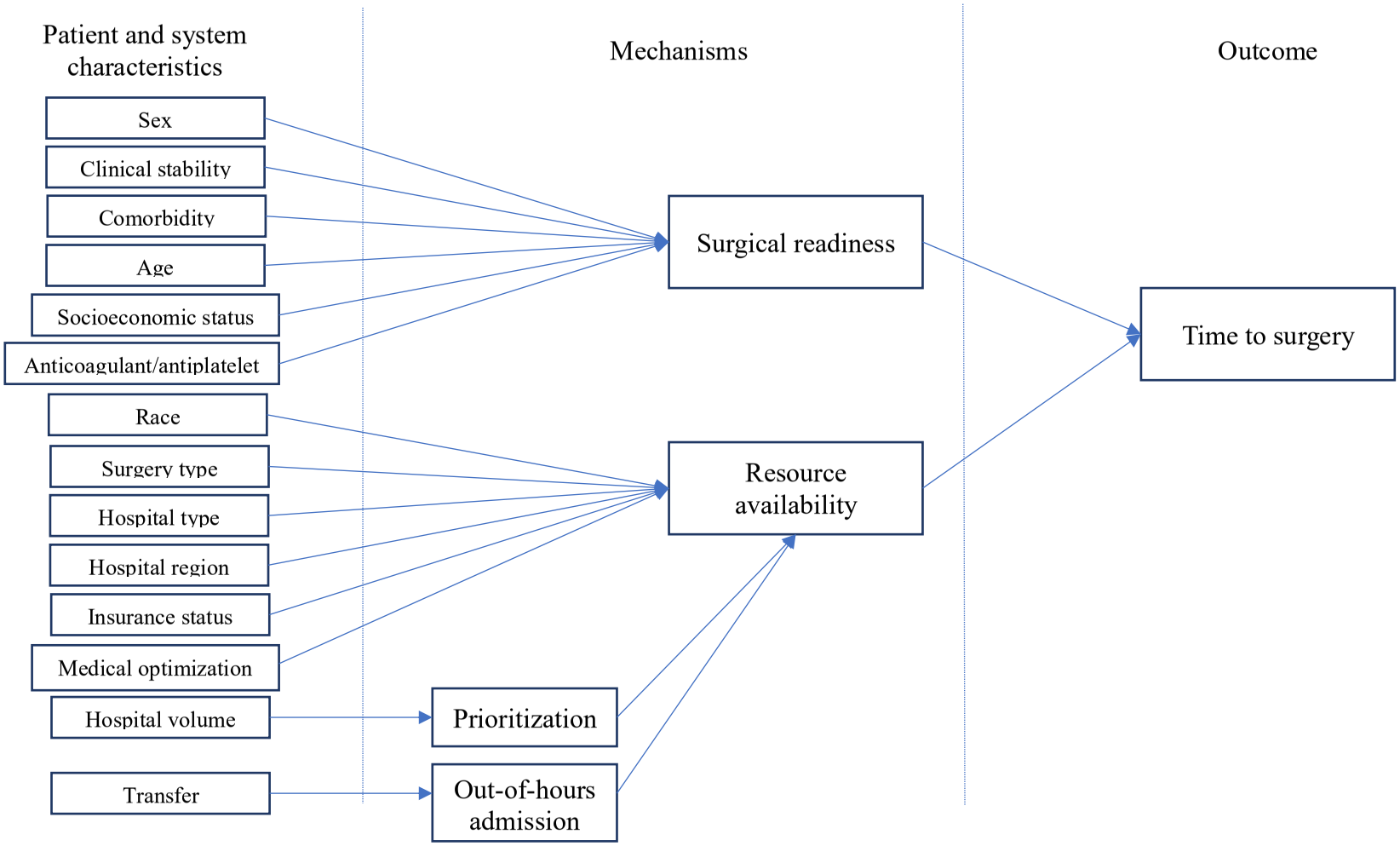

Figure 1. Mechanisms by which patient and system characteristics affect time to hip fracture surgery (76).

Patient and system characteristics known to affect time to surgery may vary across provinces. Population demographics and the burden of morbidity differ between provinces (77,78). The characteristics of health care systems differ across provinces, as provinces are responsible for the administration, organization, and delivery of health care services (42,43). Consequently, time to hip fracture surgery may differ across provinces due to differences between provinces in patient and system characteristics known to affect time to surgery. It is important to understand the extent to which these characteristics influence provincial variation in time to surgery as the variation may reflect differences in medically necessary delays and/or nonmedical delays.

Characteristics which delay hip fracture surgery may also be classified as medical or nonmedical. Patients may present to hospital in poor health and must be medically stabilized before they can proceed to surgery (44-46). Failure to properly stabilize a patient may increase the risk of perioperative complications (46). Nonmedical delays relate to the availability of resources, such as an OR, specialist, or laboratory test, and may be avoidable (76). By identifying the causes of delay to surgery, the potential exists to improve access to the procedure (49,79). This is particularly important given the consequences of delay to surgery.

Section 2.7: Importance of early hip fracture surgery and clinical guidelines

Many experts believe that early surgical treatment of hip fracture patients improves outcomes. After sustaining a hip fracture, patients are bleeding, they are in

pain, and they are immobile, confined to bed rest. These characteristics introduce inflammatory, hypercoagulable, catabolic, and stress states that may lead to medical complications. Longer delays may reduce the therapeutic effects of surgery, as patients are exposed to these harmful states for longer periods of time (18). For instance, prior to surgery, patients are prescribed bed rest. Bed rest is associated with a number of complications, including thromboembolism, urinary tract infections, atelectasis, and pressures ulcers (46). Delay to surgery has been associated with postoperative complications, such as pressure sores and pneumonia. Most importantly, delay to surgery has been associated with an increased postoperative mortality rate (17,80). Consequently, various organizations have published clinical guidelines that recommend an appropriate time to surgery for hip fracture patients.

Clinical guidelines recommend appropriate time to hip fracture surgery. In Canada, Health Quality Ontario and Ministry of Health and Long-Term Care recommend surgery be performed within 48 hours from admission (81). In the United States, the American Academy of Orthopaedic Surgeons recommends that surgery be performed within 48 hours of admission (82). In the United Kingdom, the National Institute for Health and Care Excellence (NICE) recommends that surgery be performed on the day of or the day after admission (2). Similarly, the Australian and New Zealand Hip Fracture Registry recommends surgery be performed on the day of or the day after presentation to hospital with hip fracture (83). Based on a review of the existing evidence and clinical guidelines, Canada established a time to surgery benchmark (19,20).

Section 2.8: Time to hip fracture surgery benchmark

In 2005, to reduce the potential harmful effects of treatment delays, the Canadian government established a time to hip fracture surgery benchmark (19). The Canadian First Ministers announced the 10-Year Plan to Strengthen Health Care in 2004 (43). The plan emphasized improving access to health care services, and it tasked provinces with developing evidence-based waiting time benchmarks in priority clinical areas (43). Benchmarks were established for five priority procedures, including hip fracture surgery (19). The time to surgery benchmark for hip fracture was set at 48 hours from admission for 90% of patients (19,20). In a health care system where demand exceeds capacity, hospital administrators must make difficult decisions in prioritizing and scheduling patients for surgery. Hip fracture surgery competes for OR time and resources with other important emergent, urgent, and elective procedures (84,85). The benchmark encourages hospital administrators to prioritize and schedule hip fracture patients for surgery within the recommended time, however, its implementation may have differed across provinces.

Whether the national time to hip fracture surgery benchmark has had a uniform effect on time to surgery across provinces is unknown. Since the establishment of the national benchmark, the CIHI has consistently observed provincial variation in compliance with the recommended time to surgery (20,27-40). Insured patients in Canada are guaranteed uniform access to care under the Canada Health Act (41). Yet, provinces are responsible for the organization and delivery of health care services, and consequently, provincial health care systems differ in terms of administration, funding, and delivery of services (42,43). Given these differences, it is possible that the national

benchmark did not have a uniform effect on time to surgery across provinces. Methodology from the field of health services research can assist in the estimation and evaluation of provincial variation in time to surgery.

Section 2.9: Provincial variation in time to hip fracture surgery

The statistical methods for measuring variation in access to care come from the field of health services research. Research in this area has focused on measuring variation in proportions, rates, and distributions across patient groups, types of procedures, time periods, and geographic regions (67). Provincial variation in time to hip fracture surgery may be estimated with different measures of effect. The effect measure chosen is, in part, determined by the measure used to summarize time to surgery by province (67). If the proportion of patients treated by a certain time in a given province is used as a summary measure, provincial variation in time to surgery may be estimated by the difference in the proportions (absolute measure of effect) or the ratio of the proportions (relative measure of effect) between provinces (86). If the time to surgery required to complete a certain proportion of patients is used as a summary measure, provincial variation in time to surgery may be estimated by the difference in quantiles of time to surgery between provinces (68). Another possible effect measure is the difference in mean time to surgery between provinces (68). Once provincial variation in time to surgery has been estimated, researchers can adjust these estimates for the effect of patient and system characteristics known to be associated with time to surgery.

Regression models may be used to estimate effect measures while adjusting for covariates of interest (67). Some of the observed provincial variation in time to surgery may be due to provincial differences in patient and system characteristics known to affect time to surgery. Researchers may be interested in adjusting the estimate of provincial variation for differences between provinces in patient and system characteristics to understand if variation persists after removing the effect of these characteristics on time to surgery. Various different types of regression models are available (67). Two examples include logistic regression and quantile regression. Logistic regression may be used to estimate the difference in proportions of patients treated within a certain time between provinces while accounting for the effects of covariate differences between provinces, and quantile regression may be used to estimate the difference in quantiles of time to surgery between provinces while accounting for the effects of covariate differences between provinces (67,68). The CIHI's Health Indicators reports have estimated time to surgery across provinces in Canada while accounting for provincial differences in age, sex, and selected comorbidities (20,35-40).

Since 2007, the CIHI has consistently reported variation across provinces in time to hip fracture surgery. The CIHI reports time to surgery summary measures by province. They do not report differences in time to surgery between provinces. The CIHI's Health Indicators reports from 2007 to 2010 reported variation across provinces in the proportion of patients treated within two and three inpatient days (20,38-40). From 2008 to 2009, the CIHI reported that the proportion of patients treated within three inpatient days was 88.2% in Newfoundland and Labrador and 72.2% in Saskatchewan (38). From 2011 to

2013, the CIHI's Health Indicators reports reported variation across provinces in the proportion of patients treated within 48 hours (35-37). From 2011 to 2012, the proportion of patients treated within 48 hours was 85.6% in Manitoba and 77.3% in British Columbia (35). From 2010 to 2017, the CIHI's Wait Times for Priority Procedures reports reported variation across provinces in the proportion of patients treated within 48 hours and the number of hours required to complete 50% and 90% of surgeries (27-34). From 2015 to 2016, the CIHI reported that the proportion of patients treated within 48 hours was 91% in Alberta and Manitoba and 76% in Prince Edward Island. The number of hours required to complete 50% of surgeries was 19 hours in Manitoba and 30 hours in Saskatchewan, while the number of hours required to complete 90% of surgeries was 45 hours in Manitoba and 80 hours in Saskatchewan (27). It is important to estimate and evaluate provincial variation in time to surgery as access to care is an important measure of health care system performance.

Section 2.10: Inequity in access and underuse of early hip fracture surgery

In assessing the quality of health care services, measures of health care structures, processes, and outcomes can be evaluated (87). Measures of outcome describe the effects of health care services on the health status of a patient or a population, measures of structure describe the characteristics of the setting that deliver the health care services, and measures of process describe the methods by which the services are delivered and received by the patient or population (88). Access is characterized by a process of entering a system of care and the timely delivery of a service that provides an appropriate level of care. Entering a system of care for hip fracture is not optional. Admission to

hospital is necessary once a diagnosis has been made. However, timely delivery of an appropriate level of care is determined by competing demands for access to services (89). As such, access is a process measure of quality of care. It is an important measure of health care system performance (90). While many studies have explored regional variation in health care system performance in terms of utilization of resources, fewer studies have examined regional variation in access to care.

Regional variation studies are used to identify differences in the quality of care across geographic areas. Historically, regional variation studies have examined variation in health care utilization rates (91,92). These studies identify regions where there is either an overuse or underuse of care being provided to patients (93). Fewer investigations have examined regional variation in access to care (94). Studies examining regional variation in access to care provide an effective means to quantify differences in access to care across geographic areas and to identify regions with reduced access to care, or said differently, where early access to care is 'underused'. The results provide useful comparative measures of health care quality and have important implications for patients' outcomes (94). Studying how time to surgery varies across provinces is important for understanding whether provinces are providing timely and equitable access to the procedure.

Provincial variation in time to hip fracture surgery may reflect inequity in access to care and an underuse of early surgery in some provinces (47). Health inequalities denote disparities in the health experience and status between regions and groups of

people. Health inequities refer to preventable health inequalities that are deemed to be unfair or unjust (95). Identifying health inequities involves a normative judgement, and therefore determining whether an inequality reflects an inequity is subject to interpretation (38). Provincial variation in time to surgery has been observed across provinces, reflecting inequality in access to care. However, some of this variation may be due to provincial differences in patient and system characteristics. By excluding patients unfit for surgery and estimating provincial differences in time to surgery while accounting for differences in patient and system characteristics, improved estimates of inequality in access to care can be identified. These estimates of inequality can assist in assessing whether inequities in access to hip fracture surgery exist in the Canadian health care system.

Section 2.11: Characteristics that affect provincial variation in time to hip fracture surgery

Provincial variation in time to hip fracture surgery may result from the variation across provinces in patient characteristics. Patients who present to hospital in poor health may be appropriately delayed to surgery for medical evaluation and stabilization (44-46). Whether the provincial variation in time to surgery would persist among patients fit for surgery is unknown. Early access to hip fracture surgery is particularly important for patients fit for surgery. In 2004, Orosz et al. examined the association between access to surgery within 24 hours and patient outcomes. They found that patients treated within 24 hours had reduced pain and shorter lengths of stay. When they examined a subgroup of patients who were fit for surgery, in addition to experiencing reduced pain and shorter

lengths of stay, patients treated within 24 hours had reduced rates of major complications (46). In addition, in 2018, Sobolev et al. examined the risk of postoperative mortality among patients fit for surgery. They found that surgery on the day of admission or on inpatient day two reduced the risk of postoperative mortality (96). Understanding whether provincial variation in time to surgery exists among patients fit for surgery is especially important given the consequences of delay for these patients. Comparing time to surgery across provinces among patients fit for surgery can provide insight into whether the observed provincial variation in time to surgery reflects an unmet need.

Variation in time to hip fracture surgery across provinces may differ among groups of patients defined by their timing of admission. Some hospitals reduce the capacity of ORs after-hours or over the weekends (49,50). However, studies examining the association between the day of admission and time to surgery have found inconsistent results (50,97-103). This inconsistency may be because patients admitted early during the day on a week day have a greater opportunity to undergo surgery on admission day than patients admitted late in the day or on a weekend. Comparing time to surgery across provinces among patients admitted early on a weekday, late on a weekday, and on a weekend, respectively, can provide insight into whether the observed variation reflects an unmet need among patients with different admission times (47).

Provincial variation in time to hip fracture surgery may differ among groups of patients defined by their type of surgery. Different surgical procedures require different resources. Patients treated with total hip arthroplasty and hemiarthroplasty have been

observed to wait longer for surgery than patients treated with internal fixation (98,101,104). Longer delays among patients treated with hip arthroplasty may be due to the availability of surgeons with arthroplasty experience or the availability of implants. (76). Total hip arthroplasty, a specific type of hip arthroplasty, is a particularly complex type of surgery (52). Many surgeons do not perform this procedure unless it is part of their routine elective practice (51). Comparing time to surgery across provinces among patients treated with hip arthroplasty and internal fixation, respectively, can provide insight into whether the observed variation reflects an unmet need among patients who are treated with different surgical procedures.

Section 2.12: Gaps in the literature

There is an opportunity to build upon the existing literature to understand if the observed provincial variation in time to hip fracture surgery represents an underuse of early surgery and to provide insight into the extent to which patient and system characteristics contribute to the variation. Previous reports on time to surgery have included all surgically treated patients and have reported time to surgery by province (20,27,34,35). These estimates of time to surgery have either not adjusted for covariate differences between provinces or have only adjusted for age, sex, and selected comorbidities (70,105). Comparing time to surgery across provinces among surgically fit patients while accounting for differences in patient and system characteristics can provide insight into whether the observed variation represents inequity in access to care and an underuse of early surgery. In addition, previous reports on time to surgery have estimated time to surgery at a limited number of points on the time to surgery distribution. The

reports have largely measured time to surgery to assess compliance with the benchmark (20,27-40). However, provincial variation in time to surgery may be different at different points on the time to surgery benchmark. Variation across provinces in time to surgery measured at a point on the distribution that represents early surgery may differ from variation across provinces measured at a point on the distribution that represents delayed surgery. Previous reporting has also reported time to surgery across provinces among all types of patients. However, provincial variation in time to surgery may differ among subgroups of patients. Some hip fracture patients are delayed to surgery due to access to resources. For instance, patients admitted late in the day or on a weekend may be delayed to surgery due to access to the OR or patients treated with hip arthroplasty may be delayed to surgery due to access to surgeon with arthroplasty experience or implants (46,50,76). Variation across provinces in time to surgery may differ among groups of patients defined by their timing of admission or their type of surgery. Comparing time to surgery across provinces at various points on the time to surgery distribution and among subgroups of patients can improve our understanding of how time to surgery varies across provinces and provide insight into the extent to which patient and system characteristics influence provincial variation in time to surgery.

Chapter 3: Study Questions and Objectives

Providing equitable and timely access to hip fracture surgery is a major undertaking by the Canadian public health system. In 2005, the benchmark time to surgery was established as 48 hours from admission for 90% of patients (19,20). However, most provinces are currently not meeting the benchmark and provincial variation in time to surgery has persisted since the establishment of the benchmark (27). Current estimates of provincial variation in time to surgery include patients who were unfit for surgery and do not adjust for provincial differences in patient and system characteristics (70,105). The aim of this study is to determine if early surgery is being underused in the Canadian provinces and to provide insight into what characteristics contribute to the provincial variation in time to surgery. More specifically, the objective of this study is to determine if the provincial variation in time to surgery represents an underuse of early surgery by estimating and comparing time to surgery across provinces among surgically fit patients and their subgroups of patients defined by timing of admission and type of surgery, respectively.

The two primary study questions are:

1) Does time to hip fracture surgery vary across provinces among surgically fit patients after adjusting for patient and system characteristics?
2) Is the provincial variation in time to hip fracture surgery consistent across various quantiles of time to surgery?

The two secondary study questions are:

3) Does time to hip fracture surgery vary across provinces among patients admitted early on a weekday, late on a weekday, and on a weekend, respectively?
4) Does time to hip fracture surgery vary across provinces among patients treated with hip arthroplasty and internal fixation, respectively?

The CIHI has released several reports describing the provincial variation in time to surgery among patients aged 65 years or older who were treated surgically in a Canadian hospital, excluding Quebec (20,35-40). We improve on this reporting in the following ways:

1) excluding patients who were not fit for surgery,
2) estimating provincial differences in time to surgery,
3) adjusting the estimated differences for patient and system characteristics,
4) estimating provincial variation in time to surgery at various points on the time to surgery distribution, and
5) estimating provincial variation in time to surgery among subgroups of patients defined by timing of admission and type of surgery, respectively.

Like the CIHI, we study patients aged 65 years or older and focus on patients who were surgically treated. The period selected is significant as the time to surgery benchmark was established in 2005 (19,20). Like the CIHI, we define time to surgery from admission, and we employ data from the CIHI's DAD, as it has been used by the CIHI to report on time to surgery for more than a decade (20,27-40).

We measure time to hip fracture surgery as the proportion of patients treated on admission day and within three inpatient days and the number of inpatient days required to complete 33%, 66%, and 90% of surgeries. The proportion of patients treated within three inpatient days and the number of inpatient days required to complete 90% of surgeries provide a good measure of compliance with the time to surgery benchmark. The proportion of patients treated on admission day and the number of inpatient days required to complete 33% and 66% of surgeries provide additional measures of time to surgery to capture provincial variation among patients undergoing early surgery (47).

To describe the provincial variation in time to hip fracture surgery, we estimate the difference in the proportion of surgeries completed on the day of admission and within three inpatient days between each province and Ontario. In addition, we estimate the difference in the number of inpatient days required to complete 33%, 66%, and 90% of surgeries between each province and Ontario (47). These effect measures were chosen as they are relatively easy to understand and interpret. They provide an effective means to communicate our results to health care administrators, public health officials, and the public. The reference province is Ontario, as nearly 50% of the study population was treated in Ontario (47).

To describe the provincial variation in time to hip fracture surgery among subgroups of patients defined by their timing of admission and their type of surgery, respectively, we perform five subgroup analyses. Patients admitted at various times

during the day and on different days during the week may differ in their access to surgery, due to the availability of resources (76). We study three subgroups of patients based on their timing of admission: early weekday admissions, late weekday admissions, and weekend admissions. Similarly, patients treated with different types of surgery may differ in their access to surgery due to the availability of resources (76). We study two subgroups of patients based on their type of surgery: patients treated with hip arthroplasty and patients treated with internal fixation.

The objectives of this study are to estimate among hip fracture patients, 65 years or older, who were treated surgically in a Canadian hospital (excluding Quebec) between January 1, 2004 and December 31, 2012:

1) the distribution of time to surgery by the province of surgical treatment;
2) the difference in proportion of surgeries completed on admission day and within three inpatient days between each province and Ontario standardized to the patient and system characteristics of Ontario;
3) the difference in the number of inpatient days required to complete 33%, 66%, and 90% of surgeries between each province and Ontario standardized to the patient and system characteristics of Ontario;
4) the provincial differences in time to surgery among patients admitted early on a weekday, late on a weekday, and on a weekend, respectively; and
5) the provincial differences in time to surgery among patients treated with hip arthroplasty and internal fixation, respectively.

Chapter 4: Methodology

Section 4.1: Study design

We employ a cross sectional study design to describe the provincial variation in time to hip fracture surgery. Cross sectional studies measure the study variable or exposure and outcome of a subject in a population at one point in time (106). As we are interested in improving on the CIHI's estimates of provincial variation in time to surgery, like the CIHI, we focus on surgically treated patients. We compare the time to surgery across provinces where surgery was performed, as we are interested how provinces vary in the timely delivery of surgery. For each patient, both the study variable, the province of surgical treatment, and the outcomes, surgery on admission day, surgery within three inpatient days, and the number of inpatient days from admission to surgery, are determined at one point in time: surgery.

Cross sectional studies offer several advantages, namely they are relatively efficient low cost studies that are useful in identifying associations and generating hypotheses. The primary limitation of cross sectional studies is determining etiology. As both the study variable and outcome are measured at the same point in time, it is difficult to differentiate a cause and effect relationship from an association (106). This study is not concerned with determining a cause and effect relationship, as the province of surgical treatment does not determine time to surgery. Rather, it is a combination of patient and system characteristics that affect the availability of resources and surgical fitness of a patient that affect time to surgery (48,76). We are interested in determining if, after accounting for provincial differences in patient and system characteristics associated with

time to surgery, patients have equal access to surgery across provinces. Cross sectional studies may also suffer from selection bias (106). Selection bias refers to the situation where the study sample does not accurately represent the target population, and the parameter of interest, measured in the study sample, either over or underestimates the true parameter (107). To address this concern, the scope of our study is the population. We include all hip fracture patients aged 65 years or older who were surgically treated in a Canadian hospital, excluding Quebec.

Section 4.2: Data source

We examine data from the CCHF's analytical dataset. The dataset contains hospital records that were extracted from the CIHI's DAD. These records include administrative, clinical, and demographic information (21).

The CCHF's analytical dataset contains episodes of initial hospitalization for first hip fracture (108). An episode of care is defined as all contiguous hospitalizations for a given patient (109). Episodes of care are created by combining all adjacent hospital records into a single record for each patient according to rules developed by the CIHI (14,109). If these episodes of care are not created, time to surgery is underestimated (109).

Section 4.3: Study population

Our study population includes surgically treated hip fracture patients. We identify surgeries using Canadian Classification of Health Intervention codes (CCI) or Canadian

Classification of Procedure (CCP) codes (CCI: 1VA74^^, 1VA53^^, 1VC74^^, 1SQ53^^ or CCP: 9054, 9114, 9134, 9351, 9359, 9361, 9362, 9363, 9364, 9369). We include 154,389 patients, 65 years or older, who underwent surgery for a non-pathological first hip fracture between January 1, 2004 and December 31, 2012 in Canadian acute care hospitals, except for hospitals in the province of Quebec.

We exclude hip fracture patients who were not fit for surgery. Patients presenting with poor health status may be appropriately delayed to surgery for preoperative tests and procedures (44-46). The NICE identifies anaemia, anticoagulation, volume depletion, electrolyte imbalance, uncontrolled diabetes, uncontrolled heart failure, acute cardiac arrhythmia or ischemia, acute chest infection, and exacerbation of a chronic chest condition as conditions that merit a surgical delay (2). We identify patients with medically necessary surgical delays using a screening algorithm developed by the CCHF (110). Using this algorithm, we exclude 10,342 patients who were delayed for reasons of medical necessity. We exclude 1,194 patients who were admitted to a special care unit or a step-down unit as an additional indicator of delay due to medical necessity. In addition, we exclude 2,182 patients who were treated in a hospital with an annual surgical volume of less than 24 surgeries. Finally, we exclude 436 patients with a time to surgery of 21 inpatients days or longer based on the belief that patients with longer time to surgery are not fit for surgery (14,111). Our final study population consists of 140,235 patients.

Figure 2 presents the flowchart of patient selection for this study. The light blue box describes the patients initially included in the study. The vertical arrow represents the

path from the initial study population (top of the figure) to the final study population (bottom of the figure). Each horizontal arrow represents an exclusion criterion. The boxes at the end of each horizontal arrow describe each exclusion criterion. The dark blue box at the bottom of the vertical arrow describes the final study population.

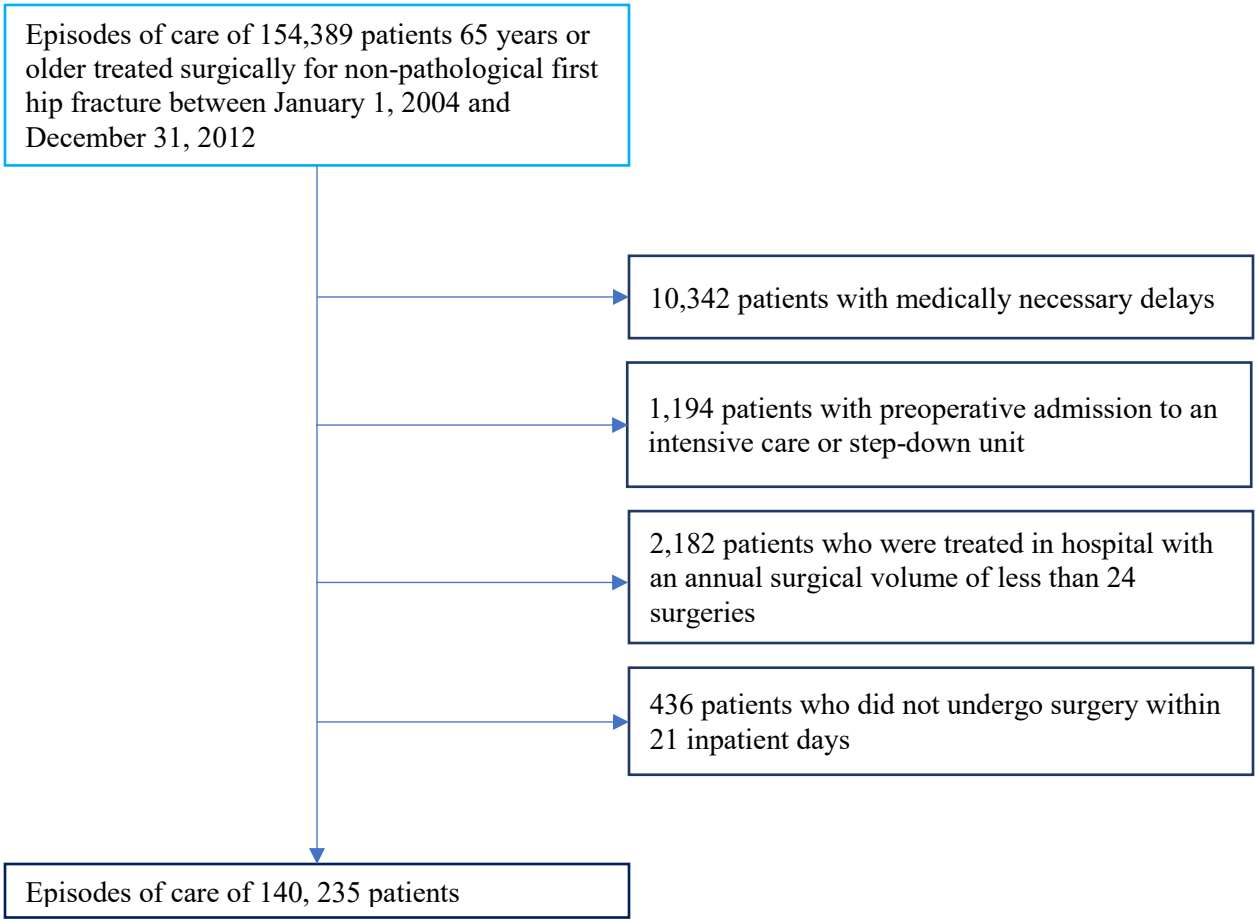

Figure 2. Patient selection flowchart for the analysis of 140,235 hip fracture patients who were treated surgically in Canada, excluding Quebec, between 2004 and 2012.

Figure 3 and 4 present the two Graphic Appraisal Tool for Epidemiologic studies (GATE) diagrams for this study. GATE diagrams are visual tools that assist in conceptualizing the overall study design and its associated components. The population is represented by the triangle, the study variable or the exposure by the circle, the outcomes

by the square, and the time of measurement by the horizontal arrow (112). The study population is described to the left of the triangle in both figures. The study variable is the province of surgical treatment. The circle, representing the study variable, is divided into two halves with the 'exposed' provinces listed to the left of the circle and the reference province, Ontario, listed to the right. The reference province is Ontario, as nearly 50% of the study population was treated in Ontario. The two figures present the two different types of outcomes being studied. In Figure 3, the two outcomes are surgery on admission day and surgery within three inpatient days. Each patient is categorized as either having had surgery performed within the specified time or not. In Figure 4, the outcome is the number of inpatient days to surgery. In GATE diagrams, time is represented by a horizontal arrow when the outcomes of a study are measured at one point in time (112). In our study, we measure the outcome, surgery on admission day, surgery within three inpatient days, and the number of inpatient days to surgery, at one point in time: surgery. The two figures illustrate the two study designs and the associated components employed to meet our objectives.

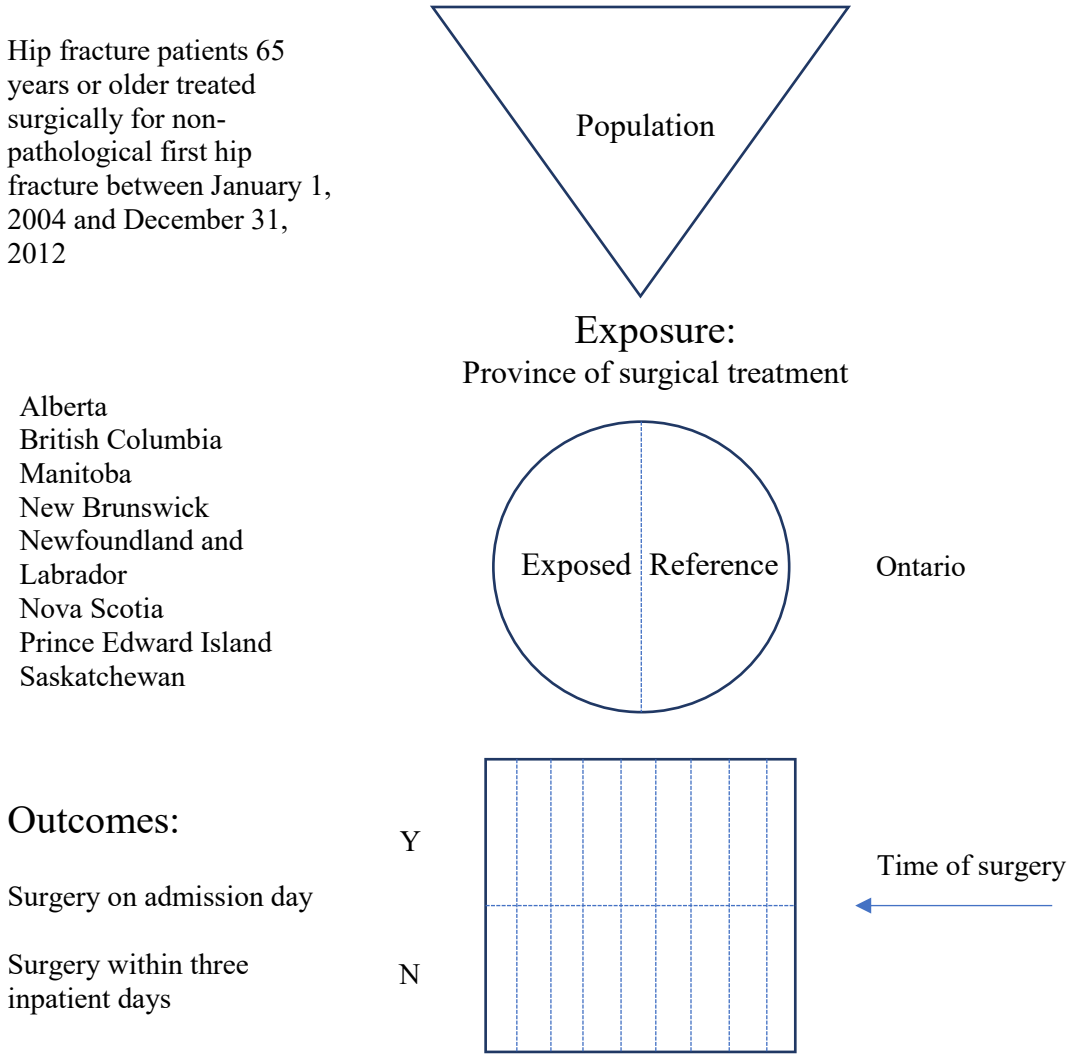

Figure 3. GATE diagram 1 for the analysis of 140,235 hip fracture patients who were treated surgically in Canada, excluding Quebec, between 2004 and 2012.

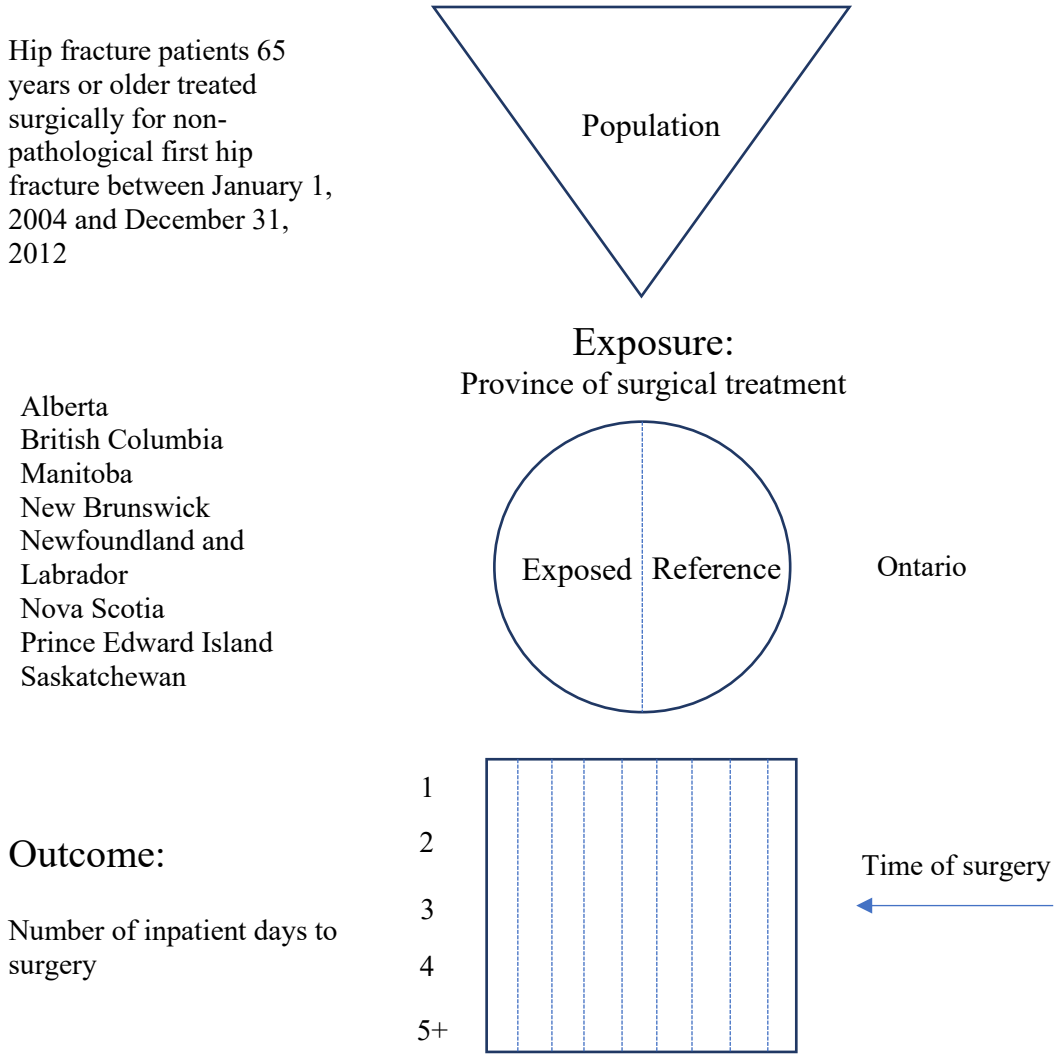

Figure 4. GATE diagram 2 for the analysis of 140,235 hip fracture patients who were treated surgically in Canada, excluding Quebec, between 2004 and 2012.

Section 4.4: Outcomes

The outcomes are surgery on admission day, within three inpatient days, and the number of inpatient days from admission to surgery. While there are different models for scheduling hip fracture surgery in the OR, hip fracture cases are commonly booked for surgery on the urgent list and scheduled for surgery by the OR manager. Surgeons add patients to the urgent list once they are deemed fit for surgery. OR managers then allocate the OR slots to the patients from the urgent list. They attempt to book the OR time once

or twice a day over the following days. We observe that, in general, the booking of hip fracture surgery follows the updates of the OR schedule, and therefore, the possibility of undergoing the operation occurs with these updates. Thus, we employ the CIHI definition of time to surgery and measure the number of inpatient days from admission, which corresponds, generally, to the number of updates of the OR schedule between the day of admission and the day of surgery (113).

We measure compliance with the time to hip fracture surgery benchmark by estimating the proportion of patients treated within three inpatient days and the number of inpatient days required to complete 90% of surgeries. The benchmark is 48 hours from admission for 90% of patients (19,20). We observe that one day is the period of 24 hours between two consecutive midnights. A period of 48 hours starting on admission day always ends during inpatient day three. Therefore, the proportion of patients treated within three inpatient days is a good approximation of the proportion of patients treated within 48 hours of admission.

To capture additional variation in the provincial time to hip fracture surgery distributions, we estimate the proportion of patients treated on admission day and the number of inpatient days required to complete 33% and 66% of surgeries.

Section 4.5: Study variable

The study variable is the province of surgical treatment. We include the following provinces: Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and

Labrador, Nova Scotia, Ontario, Prince Edward Island, and Saskatchewan (47). We do not include Quebec, as hospital records from this province are not available in the CIHI DAD (21). The reference province is Ontario, as nearly 50% of the study population was treated in Ontario. We exclude patients who underwent surgery in a hospital with an annual surgical volume of less than 24 surgeries. Consequently, we exclude 146 patients who were surgically treated in the Yukon, the Northwest Territories, and Nunavut.

Section 4.6: Covariates

We account for a variety of patient and system characteristics in the statistical analysis. The covariates are as follows: age (<85 years, ≥85 years), sex (women, men), pre-fracture health status (admitted from home with no major comorbidity, admitted from home with major comorbidity or home care, admitted from long-term care, admitted from elsewhere), hospital volume (logarithm of the number of hip fracture surgeries at the treating hospital in the fiscal year the patient is treated), timing of admission (early weekday, late weekday, weekend), admission status (urgent/emergent, other), excess demand (above or equal to the average weekly surgical capacity, below the average weekly surgical capacity), transfer history (yes, no), preoperative procedures (yes, no), type of fracture (transcervical, intertrochanteric, or subtrochanteric), type of surgery (internal fixation, hip arthroplasty), and calendar year of surgery (2004–2006, 2007–2009, 2010–2012).

We operationalize covariate variables to best capture their association with time to hip fracture surgery. To account for differences in the surgical fitness of patients, we

adjust for age, sex, and pre-fracture health status. Age is operationalized as a categorical variable reflecting whether a patient was less than 85 years or 85 years or older based on the premise that older adults require medical stabilization more often than younger adults (76). Stratifying patients by their pre-fracture health status is a concept developed by Health Quality Ontario and the Ministry of Health and Long-term Care and operationalized by the CCHF (81). Patients are categorized as admitted from home with no comorbidity, admitted from home with comorbidity, admitted from long-term care, admitted from elsewhere. Comorbidities are defined as heart failure, chronic obstructive pulmonary disorder, ischemic heart disease (acute and chronic), dysrhythmias, hypertension, diabetes, and cancer (breast-female, prostate, renal, lung, multiple myeloma, and metastatic cancer). Cancer is identified by diagnostic codes from all hospitalizations during the hip fracture care episode and all other comorbidities are identified by diagnostic codes from all hospitalizations in one year prior to the index admission. To account for differences in resources, we adjust for hospital volume, timing of admission, admission status, demand, transfer history, pre-operative procedures, and type of surgery. Hospital volume is operationalized as a continuous variable reflecting the logarithm of the number of hip fracture surgeries at the treating hospital in the fiscal year the patient is treated based on the premise that a change in the order of magnitude of the annual number of surgeries rather than a unit change in the annual number of surgeries influences time to surgery. Demand is operationalized as a categorical variable reflecting whether demand in the hospital where the patient was treated was above or equal to or below the average weekly capacity of the hospital based on the premise that an excess in demand influences time to surgery.

From a public health perspective, some of these characteristics are modifiable and some are immutable. The characteristics of the patient (age, sex, pre-fracture health status), the characteristics of the fracture, the demand for resources, and the timing of admission are immutable. Hospital volume, transfer history, preoperative procedures, and the type of surgery are modifiable.

Section 4.7: Subgroups analyses

In our timing of admission subgroup analyses, we examine how time to hip fracture surgery varies across provinces in subgroups of patients defined by their timing of admission. Some hospitals reduce the capacity of ORs after-hours or over the weekends (49,50). As a result, access to resources may vary across provinces by timing of admission. We therefore divide patients into three groups: early weekday admission, late weekday admission, and weekend admission. Early weekday admissions are classified as an admission from Monday to Friday between 00:00 and 15:59, late weekday admissions are classified as an admission from Monday to Friday between 16:00 and 11:59, and weekend admissions are classified as an admission on Saturday or Sunday.

In our type of surgery subgroup analyses, we examine how time to hip fracture surgery varies across provinces in subgroups of patients defined by their type of surgery. Hip arthroplasty requires different resources than internal fixation. As a result, access to resources may vary across provinces by type of surgery. Patients treated with

hemiarthroplasty and total hip arthroplasty have been observed to wait longer for surgery than patients treated with internal fixation (98,101,104). We therefore divide patients into two groups: patients treated with hip arthroplasty (total hip arthroplasty and hemiarthroplasty) and patients treated with internal fixation. The different surgical procedures are identified using CCI and CCP codes (CCI codes 1VA53^^, 1SQ53^^ and CCP codes 9351, 9359, 9361, 9362, 9363, 9364, 9369 for hip arthroplasty and CCI codes 1VA74^^, 1VC74^^ and CCP codes 9054, 9114, 9134 for internal fixation).

Section 4.8: Statistical analysis

We describe the study cohort by patient and system characteristics. For each characteristic, we report the frequency and percentage, overall and by province.

We estimate the time to hip fracture surgery summary measures, overall and by province. The proportion of surgeries completed on admission day and within three inpatient days are estimated by taking the ratio of the number of surgeries completed on admission day and within three inpatient days to the total number of surgeries, respectively. We estimate the number of days required to complete 33%, 66%, and 90% of surgeries using a weighted average of adjacent order statistics, and we estimate their confidence intervals using the binomial method (114).

We estimate the effect of province on time to hip fracture surgery in several ways. We use the log rank test to test for differences in the provincial time to surgery distributions. We use logistic regression to estimate the difference in the proportion of

surgeries completed on admission day and within three inpatient days between each province and Ontario (115,116). To account for the clustered nature of the time to surgery data, we relax the independence assumption between patients within hospitals when estimating the standard errors of the regression coefficients. We standardize the difference in the proportion of surgeries completed on admission day and within three inpatient days between each province and Ontario to the mean value of each covariate in Ontario (117). We employ quantile regression for count data to estimate the difference in the number of inpatient days required to complete 33%, 66%, and 90% of surgeries between each province and Ontario (114). Standard quantile regression is used on count data that has been transformed into continuous data by adding a uniform random variable (118). We standardize the differences in the number of days required to complete 33%, 66%, and 90% of surgeries between each province and Ontario to the mean value of each covariate in Ontario (117,119). All regression analyses are adjusted for the following covariates: age, sex, pre-fracture health status, hospital volume, timing of admission, admission status, excess demand, transfer history, preoperative procedures, type of fracture, type of surgery, and calendar year of surgery.

Chapter 5: Overall results

Section 5.1: Patient and system characteristics

We characterized the study population by describing the distributions of patient and system characteristics, overall and by province (Table 1). The population included 140,235 patients who underwent hip fracture surgery between 2004 and 2012. Most patients were women (74.3%) who were less than 85 years old (54.2%). The largest proportions of patients were admitted from home without comorbidity (44.7%), late on a weekday (38.1%), with a transcervical fracture (52.0%), and were treated with internal fixation (60.1%). Patients who were treated in Ontario represented nearly half of the cohort (48.2%).

The distributions of patient and system characteristics varied across provinces (Table 1). The proportion of women varied from a low of 72.9% in British Columbia to a high of 78.8% in Newfoundland and Labrador, and the proportion of those who were aged less than 85 years old varied from 50.3% in Saskatchewan to 58.5% in Newfoundland and Labrador. The proportion of those who were admitted late on a weekday varied from 33.2% in Nova Scotia to 42.4% in Saskatchewan, and the proportion of those who were treated with internal fixation varied from 51.8% in Prince Edward Island to 63.2% in Manitoba.

Table 1. Characteristics of 140,235 hip fracture patients who were treated surgically in Canada, excluding Quebec, between 2004 and 2012, overall and by province.*

	Province; No. (%) of Patients									
	Overall (n=140,235)	AB (n=15,401)	BC (n=26,953)	MB (n=7,758)	NB (n=4,818)	NL (n=3,182)	NS (n=6,039)	ON (n=67,622)	PE (n=1,035)	SK (n=7,427)
Age										
<85 years	75,940 (54.2)	8,569 (55.6)	14,100 (52.3)	3,957 (51.0)	2,627 (54.5)	1,860 (58.5)	3,253 (53.9)	37,284 (55.1)	552 (53.3)	3,738 (50.3)
≥85 years	64,295 (45.8)	6,832 (44.4)	12,853 (47.7)	3,801 (49.0)	2,191 (45.5)	1,322 (41.5)	2,786 (46.1)	30,338 (44.9)	483 (46.7)	3,689 (49.7)
Sex†										
Women	104,170 (74.3)	11,282 (73.3)	19,645 (72.9)	5,755 (74.2)	3,717 (77.1)	2,509 (78.8)	4,637 (76.8)	50,337 (74.4)	802 (77.5)	5,486 (73.9)
Men	36,050 (25.7)	4,117 (26.7)	7,306 (27.1)	2,003 (25.8)	1,098 (22.8)	673 (21.2)	1,402 (23.2)	17,277 (25.5)	233 (22.5)	1,941 (26.1)
Pre-fracture health from‡										
Home without comorbidity	62,732 (44.7)	6,339 (41.2)	13,504 (50.1)	3,098 (39.9)	1,879 (39.0)	1,497 (47.0)	2,095 (34.7)	31,536 (46.6)	334 (32.3)	2,450 (33.0)
Home with comorbidity or home care	21,936 (15.6)	2,588 (16.8)	4,999 (18.5)	1,063 (13.7)	653 (13.6)	395 (12.4)	764 (12.7)	10,776 (15.9)	80 (7.7)	618 (8.3)
LTC Facility	29,443 (21.0)	3,354 (21.8)	5,581 (20.7)	1,598 (20.6)	780 (16.2)	521 (16.4)	787 (13.0)	15,402 (22.8)	253 (24.4)	1,167 (15.7)
Elsewhere	26,124 (18.6)	3,120 (20.3)	2,869 (10.6)	1,999 (25.8)	1,506 (31.3)	769 (24.2)	2,393 (39.6)	9,908 (14.7)	368 (35.6)	3,192 (43.0)
Annual Hospital volume										
Lower in its type§	34,505 (24.6)	2,825 (18.3)	7,959 (29.5)	1,379 (17.8)	3,432 (71.2)	577 (18.1)	178 (2.9)	16,085 (23.8)	818 (79.0)	1,252 (16.9)
Higher in its type	105,730 (75.4)	12,576 (81.7)	18,994 (70.5)	6,379 (82.2)	1,386 (28.8)	2,605 (81.9)	5,861 (97.1)	51,537 (76.2)	217 (21.0)	6,175 (83.1)
Timing of admission‖										
Early weekday	4,7628 (34.0)	5,379 (34.9)	9,239 (34.3)	2,672 (34.4)	1,607 (33.4)	1,103 (34.7)	2,252 (37.3)	22,832 (33.8)	352 (34.0)	2,192 (29.5)
Late weekday	53,479 (38.1)	5,722 (37.2)	10,368 (38.5)	2,928 (37.7)	1,912 (39.7)	1,238 (38.9)	2,004 (33.2)	25,801 (38.2)	354 (34.2)	3,152 (42.4)
Weekend	39,062 (27.9)	4,300 (27.9)	7,345 (27.3)	2,158 (27.8)	1,298 (26.9)	841 (26.4)	1,783 (29.5)	18,987 (28.1)	291 (28.1)	2,059 (27.7)
Admission status										
Urgent /Emergent	137,674 (98.2)	15,158 (98.4)	26,589 (98.6)	7,662 (98.8)	4,769 (99.0)	3,151 (99.0)	5,959 (98.7)	66,302 (98.0)	1,008 (97.4)	7,076 (95.3)
Otherwise	2,561 (1.8)	243 (1.6)	364 (1.4)	96 (1.2)	49 (1.0)	31 (1.0)	80 (1.3)	1,320 (2.0)	27 (2.6)	351 (4.7)
Surgical demand¶										

	Province; No. (%) of Patients									
	Overall (n=140,235)	AB (n=15,401)	BC (n=26,953)	MB (n=7,758)	NB (n=4,818)	NL (n=3,182)	NS (n=6,039)	ON (n=67,622)	PE (n=1,035)	SK (n=7,427)
Otherwise	42,643 (30.4)	5,235 (34.0)	8,017 (29.7)	2,393 (30.8)	1,199 (24.9)	964 (30.3)	1,933 (32.0)	20,224 (29.9)	269 (26.0)	2,409 (32.4)
Excess demand	97,592 (69.6)	10,166 (66.0)	18,936 (70.3)	5,365 (69.2)	3,619 (75.1)	2,218 (69.7)	4,106 (68.0)	47,398 (70.1)	766 (74.0)	5,018 (67.6)
Transfer history										
No	128,644 (91.7)	13,879 (90.1)	24,114 (89.5)	6,969 (89.8)	4,621 (95.9)	3,066 (96.4)	5,814 (96.3)	62,691 (92.7)	988 (95.5)	6,502 (87.5)
Yes	11,591 (8.3)	1,522 (9.9)	2,839 (10.5)	789 (10.2)	197 (4.1)	116 (3.6)	225 (3.7)	4,931 (7.3)	47 (4.5)	925 (12.5)
Pre-operative procedures										
No	126,048 (89.9)	13,891 (90.2)	25,497 (94.6)	7,330 (94.5)	4,504 (93.5)	2,896 (91.0)	5,640 (93.4)	58,314 (86.2)	979 (94.6)	6,997 (94.2)
Yes	14,187 (10.1)	1,510 (9.8)	1,456 (5.4)	428 (5.5)	314 (6.5)	286 (9.0)	399 (6.6)	9,308 (13.8)	56 (5.4)	430 (5.8)
Fracture type										
Transcervical	72,980 (52.0)	8,077 (52.4)	14,346 (53.2)	4,024 (51.9)	2,641 (54.8)	1,766 (55.5)	3,325 (55.1)	34,249 (50.6)	565 (54.6)	3,987 (53.7)
Intertrochanteric or subtrochanteric	67,255 (48.0)	7,324 (47.6)	12,607 (46.8)	3,734 (48.1)	2,177 (45.2)	1,416 (44.5)	2,714 (44.9)	33,373 (49.4)	470 (45.4)	3,440 (46.3)
Type of surgery										
Hip arthroplasty	56,017 (39.9)	6,404 (41.6)	10,266 (38.1)	2,853 (36.8)	2,162 (44.9)	1,337 (42.0)	2,501 (41.4)	27,010 (39.9)	499 (48.2)	2,985 (40.2)
Internal fixation	84,218 (60.1)	8,997 (58.4)	16,687 (61.9)	4,905 (63.2)	2,656 (55.1)	1,845 (58.0)	3,538 (58.6)	40,612 (60.1)	536 (51.8)	4,442 (59.8)
Surgical Timing										
Admission day	32,121 (23.0)	3,076 (20.0)	5,813 (21.6)	1,315 (17.0)	1,663 (34.5)	748 (23.5)	1,917 (31.7)	16,261 (24.0)	366 (35.4)	962 (13.0)
Within three inpatient days	121,867 (87.0)	13,499 (87.7)	24,019 (89.1)	6,529 (84.2)	4,272 (88.7)	2,806 (88.2)	5,113 (84.7)	58,684 (86.8)	913 (88.2)	6,032 (81.2)
Year of surgery										
2004–2006	47,004 (33.5)	5,070 (32.9)	9,053 (33.6)	2,483 (32.0)	1,694 (35.2)	1,043 (32.8)	2,004 (33.2)	22,718 (33.6)	342 (33.0)	2,597 (35.0)
2007–2009	46,138 (32.9)	5,076 (33.0)	8,930 (33.1)	2,595 (33.4)	1,570 (32.6)	1,075 (33.8)	2,033 (33.7)	22,088 (32.7)	353 (34.1)	2,418 (32.6)
2010–2012	47,093 (33.6)	5,255 (34.1)	8,970 (33.3)	2,680 (34.5)	1,554 (32.3)	1,064 (33.4)	2,002 (33.2)	22,816 (33.7)	340 (32.9)	2,412 (32.5)

Abbreviations: AB=Alberta; BC=British Columbia; MB=Manitoba; NB=New Brunswick; NL=Newfoundland and Labrador; NS=Nova Scotia; ON=Ontario; PE= Prince Edward Island; SK=Saskatchewan; LTC = Long Term Care

*Based on discharge abstracts, including those showing codes for hip fracture surgery either from Canadian Classification of Intervention (1VA74^^, 1VA53^^, 1VC74^^, 1SQ53^^), or Canadian Classification of procedures codes (9054, 9114, 9134, 9351, 9359, 9361, 9362, 9363, 9364, 9369)

†15 patients with unknown sex

‡Comorbidities included heart failure, chronic obstructive pulmonary disorder, ischemic heart disease (acute and chronic), dysrhythmias, hypertension, diabetes, and cancer (breast–female, prostate, renal, lung, multiple myeloma, and metastatic cancer) identified by diagnostic codes from all hospitalizations in 1 year prior to index admission, and cancer and Paget's disease, identified by diagnostic codes from all hospitalizations during the hip fracture care episode

§Lower surgical volume defined as less than 174 surgeries for teaching hospitals, less than 141 surgeries for large community hospitals, and less than 37 surgeries for medium community hospitals

‖66 patients with unknown time of admission

¶The number of admissions in the week of the index admission compared with the hospital's weekly capacity

Section 5.2: All patients

In total, 22.9% of hip fracture surgeries were completed on admission day, 43.2% on inpatient day two, 20.9% on inpatient day three, 7.2% on inpatient day four, and 5.9% on inpatient day five or after. This distribution varied across provinces ($p < 0.001$).

Figure 5 is a horizontal stacked bar graph that presents the cumulative percentage of surgeries by inpatient day and by province, among hip fracture patients in Canada, excluding Quebec, between 2004 and 2012. The y-axis is the province of surgical treatment. The provinces are Alberta, British Columbia, Manitoba, New Brunswick, Newfoundland and Labrador, Nova Scotia, Ontario, Prince Edward Island, and Saskatchewan. The x-axis is the cumulative percentage of surgeries completed. Each province has five horizontal stacked bars in different shades of blue that represent the percentage of surgeries performed on admission day, inpatient day two, three, four, and five or greater. Provinces are ordered in ascending order from bottom to top according to the percentage of patients treated on admission day. In examining the horizontal stacked bar of Prince Edward Island, the cumulative percentage of patients treated on admission day was 35%, 70% within two inpatient days, 88% within three inpatient days, 96% within four inpatient days, and the remaining 4% of patients were treated on inpatient day 5 or greater.

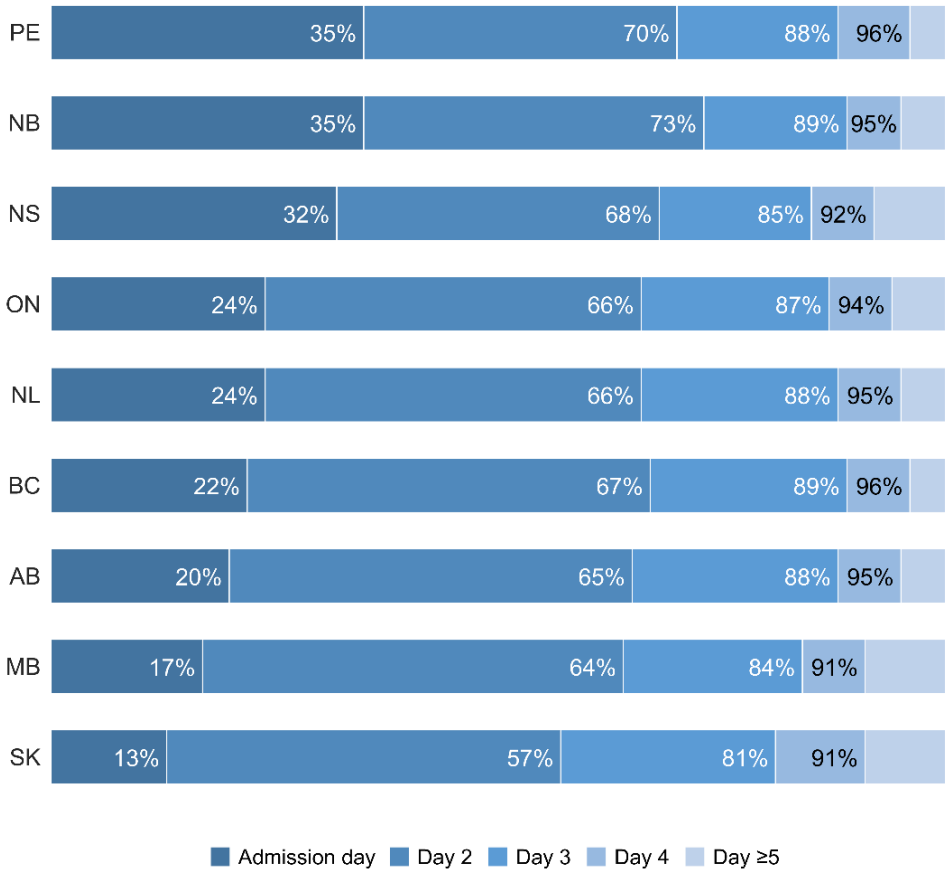

Figure 5. The cumulative percentage of surgeries by inpatient day and province, among hip fracture patients in Canada, excluding Quebec, between 2004 and 2012. Inpatient days represented by shade, cumulative percentage represented by the width of stacked bars. Provinces defined in Table 1.

Overall, 121,867 (86.9%) hip fracture surgeries were completed within three inpatient days. This proportion varied across provinces from a low of 81.2% in Saskatchewan to a high of 89.1% in British Columbia. After adjustment, there was no difference in the proportion of surgeries completed within three inpatient days between any province and Ontario (Table 2).

Overall, 32,121 (22.9%) hip fracture surgeries were completed on admission day. This proportion varied across provinces from a low of 13.0% in Saskatchewan to a high

of 35.4% in Prince Edward Island. After adjustment, Prince Edward Island completed 7.0% more surgeries (difference = 7.0; 95% CI 4.0, 9.9), Manitoba completed 6.3% less surgeries (difference = -6.3; 95% CI -12.1, -0.6), and Saskatchewan completed 7.7% less surgeries (difference = -7.7; 95% CI -12.7, -2.8) on admission day compared to Ontario (Table 2).

Table 2. The number and percentage of surgeries completed on admission day and within three inpatient days among hip fracture patients in Canada, excluding Quebec, between 2004 and 2012.

	Total	Admission day			Within three inpatient days		
Province	No. of surgeries	No. of surgeries	Percentage of surgeries	Difference in % (95% CI) *†	No. of surgeries	Percentage of surgeries	Difference in % (95% CI) *†
ON	67,622	16,261	24.0	referent	58,684	86.8	referent
AB	15,401	3,076	20.0	-1.5 (-6.5, 3.6)	13,499	87.7	1.9 (-1.3, 5.1)
BC	26,953	5,813	21.6	-1.8 (-6.1, 2.5)	24,019	89.1	2.4 (-0.5, 5.2)
MB	7,758	1,315	17.0	-6.3 (-12.1, -0.6)	6,529	84.2	-2.6 (-7.4, 2.1)
NB	4,818	1,663	34.5	3.6 (-3.7, 11.0)	4,272	88.7	-1.2 (-4.3, 1.8)
NL	3,182	748	23.5	-1.8 (-10.8, 7.3)	2,806	88.2	-0.1 (-2.1, 1.9)
NS	6,039	1,917	31.7	6.6 (-6.6, 19.7)	5,113	84.7	-3.7 (-15.8, 8.5)
PE	1,035	366	35.4	7.0 (4.0, 9.9)	913	88.2	-1.0 (-2.7, 0.7)
SK	7,427	962	13.0	-7.7 (-12.7, -2.8)	6,032	81.2	-3.5 (-11.2, 4.2)

Provinces defined in Table 1; CI = Confidence Interval

*Standardized for distribution of age, sex, pre-fracture health status, hospital volume, timing of admission, admission status, demand, transfer history, pre-operative procedures, fracture type, type of surgery, and calendar year of surgery for Ontario

†Excludes 81 patients with unknown sex or timing of admission

Overall, the number of inpatient days required to complete 90% of hip fracture surgeries was four inpatient days for all provinces, while the number of inpatient days required to complete 33% and 66% of hip fracture surgeries ranged from one to two and two to three inpatient days, respectively, across provinces (Figure 6). All provinces required two inpatient days to complete 33% of surgeries, except for Prince Edward Island and New Brunswick, which required one inpatient day. British Columbia, New Brunswick, Nova Scotia, and Prince Edward Island required two inpatient days to complete 66% of surgeries, while Alberta, Manitoba, Newfoundland and Labrador,

Ontario, and Saskatchewan required three inpatient days. After adjustment, there was no difference in the number of inpatient days required to complete 33% and 90% of surgeries between any province and Ontario, while the number of inpatient days required to complete 66% of surgeries was one day less in Alberta, British Columbia, and New Brunswick compared to Ontario (Table 3).

Table 3. The number of inpatient days required to complete 33%, 66%, and 90% of surgeries among hip fracture patients in Canada, excluding Quebec, between 2004 and 2012.

	Number of days to complete 33% of surgeries (99% CI)			Number of days to complete 66% of surgeries (99% CI)			Number of days to complete 90% of surgeries (99% CI)		
Province	Crude	Adjusted*†	Difference*†	Crude	Adjusted*†	Difference*†	Crude	Adjusted*†	Difference*†
ON	2 (2, 2)	2 (2, 2)	referent	3 (3, 3)	3 (3, 3)	referent	4 (4, 4)	4 (4, 4)	referent
AB	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	2 (2, 2)	-1 (-1, -1)‡	4 (4, 4)	4 (4, 4)	0 (0, 0)
BC	2 (2, 2)	2 (2, 2)	0 (0, 0)	2 (2, 2)	2 (2, 2)	-1 (-1, 0)‡	4 (4, 4)	4 (4, 4)	0 (0, 0)
MB	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
NB	1 (1, 2)	2 (2, 2)	0 (0, 0)	2 (2, 2)	2 (2, 3)	-1 (-1, 0)‡	4 (4, 4)	4 (4, 4)	0 (0, 0)
NL	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (2, 3)	3 (3, 3)	0 (0, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
NS	2 (2, 2)	2 (2, 2)	0 (0, 0)	2 (2, 3)	3 (2, 3)	0 (-1, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
PE	1 (1, 2)	2 (1, 2)	0 (-1, 0)	2 (2, 2)	2 (2, 3)	-1 (-1, 0)	4 (3, 4)	4 (4, 4)	0 (0, 0)
SK	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	4 (4, 5)	4 (4, 4)	0 (0, 0)

Provinces defined in Table 1; CI = confidence interval

*Standardized for distribution of age, sex, pre-fracture health status, hospital volume, timing of admission, admission status, demand, transfer history, pre-operative procedures, fracture type, type of surgery, and calendar year of surgery for Ontario

†Excludes 81 patients with unknown sex or timing of admission

‡Statistically significant on the magnified scale and clinically significant on the original day scale

Figure 6 presents the number of inpatients days required to complete 33%, 66%, and 90% of surgeries by province in Canada, excluding Quebec, between 2004 and 2012, overall, by timing of admission and by type of surgery. It is a six-panel figure. From left to right and from top to bottom, the panels present the results for all patients, early weekday admissions, late weekday admissions, weekend admissions, hip arthroplasties, and internal fixations. Each panel presents a horizontal stacked bar graph. The y-axis on each panel is the province of surgical treatment and the x-axis is the number of inpatient days. In each panel, all provinces have three horizontal stacked bars that represent the

number of inpatient days required to complete 33% (white), 66%, (light blue) and 90% (dark blue) of surgeries. The order of the provinces is the same in all panels and reflects the same order as those found in Figure 5. Examining the overall panel and the province of Prince Edward Island, the number of inpatient days required to complete 33%, 66%, and 90% of surgeries was 1, 2, and 4 inpatient days, respectively.

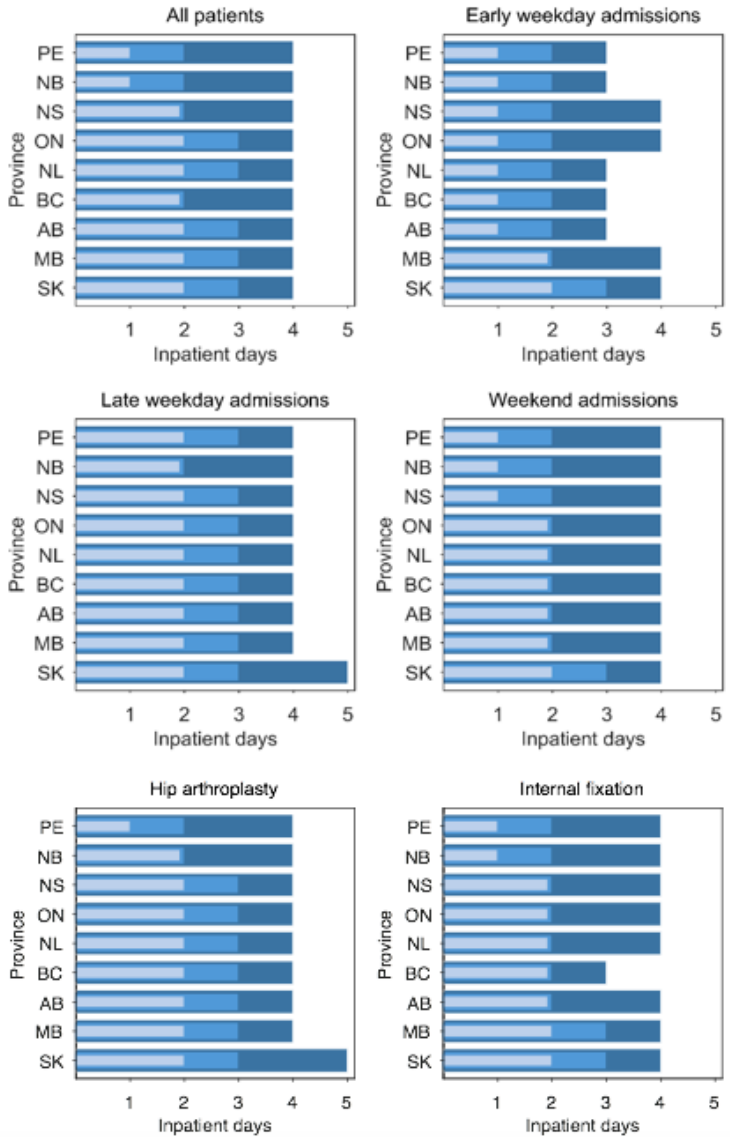

Figure 6. The number of inpatient days required to complete 33% (white), 66% (light blue) and 90% (dark blue) of hip fracture surgeries by province in Canada, excluding Quebec, between 2004 and 2012, overall, by timing of admission, and by type of surgery. Provinces defined in Table 1.

Chapter 6: Subgroup Analyses Results

Section 6.1: Early weekday admissions

Among early weekday admissions, 42,579 (89.4%) hip fracture surgeries were completed within three inpatient days. This proportion varied across provinces from a low of 83.1% in Saskatchewan to a high of 92.0% in Prince Edward Island. After adjustment, there was no difference in the proportion of surgeries completed within three inpatient days between any province and Ontario (Table 4).

Among early weekday admissions, 17,249 (36.2%) hip fracture surgeries were completed on admission day. This proportion varied across provinces from a low of 24.5% in Saskatchewan to a high of 47.4% in Prince Edward Island. After adjustment, Prince Edward Island completed 5.4% more surgeries on admission day compared to Ontario (difference = 5.4; 95% CI 1.6, 9.3) (Table 4).

Table 4. The number and percentage of surgeries completed on admission day and within three inpatient days among hip fracture patients in Canada, excluding Quebec, between 2004 and 2012, by timing of admission.

	Total	Admission day			Within three inpatient days		
Province	No. of surgeries	No. of surgeries	Percentage of surgeries	Difference in % (95% CI) *†	No. of surgeries	Percentage of surgeries	Difference in % (95% CI) *†
Early weekday admissions							
ON	22,832	8,595	37.6	referent	20,385	89.3	referent
AB	5,379	1,918	35.7	2.4 (-5.8, 10.6)	4,860	90.4	1.9 (-0.6, 4.3)
BC	9,239	3,143	34.0	-2.5 (-9.1, 4.1)	8,475	91.7	2.3 (0.0, 4.7)
MB	2,672	812	30.4	-6.3 (-16.5, 4.0)	2,285	85.5	-3.5 (-9.1, 2.0)
NB	1,607	753	46.9	1.0 (-8.4, 10.3)	1,465	91.2	-0.4 (-2.8, 2.0)
NL	1,103	403	36.5	-3.1 (-15.0, 8.9)	1,014	91.9	1.2 (-1.7, 4.1)
NS	2,252	920	40.9	4.0 (-12.5, 20.4)	1,949	86.5	-3.7 (-13.6, 6.1)
PE	352	167	47.4	5.4 (1.6, 9.3)	324	92.0	1.1 (-0.3, 2.5)
SK	2,192	538	24.5	-9.4 (-19.4, 0.6)	1,822	83.1	-3.9 (-10.4, 2.6)
Late weekday admissions							
ON	25,801	2,484	9.6	referent	21,590	83.7	referent
AB	5,722	271	4.7	-3.2 (-6.2, -0.2)	4,852	84.8	2.2 (-1.7, 6.2)
BC	10,368	854	8.2	-1.0 (-3.5, 1.4)	8,950	86.3	2.8 (-0.9, 6.5)

	Total	Admission day			Within three inpatient days		
Province	No. of surgeries	No. of surgeries	Percentage of surgeries	Difference in % (95% CI) *†	No. of surgeries	Percentage of surgeries	Difference in % (95% CI) *†
MB	2,928	129	4.4	-4.1 (-8.0, -0.2)	2,389	81.6	-2.2 (-8.0, 3.6)
NB	1,912	385	20.1	2.5 (-2.0, 7.0)	1,650	86.3	-1.3 (-5.5, 2.9)
NL	1,238	131	10.6	-0.1 (-5.7, 5.4)	1,046	84.5	-0.6 (-4.1, 2.8)
NS	2,004	330	16.5	5.0 (-2.3, 12.3)	1,638	81.7	-3.7 (-17.9, 10.5)
PE	354	69	19.5	5.0 (2.9, 7.0)	297	83.9	-2.8 (-5.0, -0.6)
SK	3,152	133	4.2	-4.1 (-7.0, -1.2)	2,483	78.8	-3.2 (-12.3, 5.9)
				Weekend admissions			
ON	18,987	5,180	27.3	referent	16,707	88.0	referent
AB	4,300	887	20.6	-3.7 (-9.3, 1.8)	3,787	88.1	1.5 (-2.0, 5.0)
BC	7,345	1,816	24.7	-1.9 (-7.0, 3.2)	6,593	89.8	1.8 (-0.8, 4.5)
MB	2,158	374	17.3	-9.5 (-15.3, -3.7)	1,855	86.0	-2.0 (-5.0, 1.0)
NB	1,298	524	40.4	5.6 (-1.8, 13.1)	1,156	89.1	-2.3 (-5.5, 1.0)
NL	841	214	25.4	-3.0 (-13.4, 7.4)	746	88.7	-1.0 (-2.9, 0.9)
NS	1,783	667	37.4	10.9 (-4.6, 26.3)	1,526	85.6	-3.5 (-16.0, 9.0)
PE	291	123	42.3	10.1 (6.7, 13.5)	260	89.3	-1.4 (-3.1, 0.3)
SK	2,059	288	14.0	-11.1 (-15.9, -6.3)	1,704	82.8	-3.7 (-11.3, 4.0)

Provinces defined in Table 1; CI = confidence interval

*Standardized for distribution of age, sex, pre-fracture health status, hospital volume, admission status, demand, transfer history, pre-operative procedures, fracture type, type of surgery, and calendar year of surgery for Ontario

†Excludes 81 patients with unknown sex or timing of admission

Among early weekday admissions, the number of inpatient days required to complete 33%, 66%, and 90% of hip fracture surgeries ranged from one to two, two to three, and three to four inpatient days, respectively, across provinces (Figure 6). All provinces required one inpatient day to complete 33% of surgeries, except for Manitoba and Saskatchewan, which required two inpatient days. All provinces required two inpatient days to complete 66% of surgeries, except for Saskatchewan, which required three inpatient days. Alberta, British Columbia, New Brunswick, Newfoundland and Labrador, and Prince Edward Island required three inpatient days to complete 90% of surgeries, while Nova Scotia, Ontario, Manitoba, and Saskatchewan required four inpatient days. After adjustment, there was no difference in the number of inpatient days required to complete 66% of surgeries between any province and Ontario, while the number of inpatient days required to complete 33% of surgeries was one day longer in Manitoba, Newfoundland and Labrador, and Saskatchewan compared to Ontario, and the

number of inpatient days required to complete 90% of surgeries was one day shorter in Alberta and British Columbia compared to Ontario (Table 5).

Table 5. The number of inpatient days required to complete 33%, 66%, and 90% of surgeries among hip fracture patients in Canada, excluding Quebec, between 2004 and 2012, by timing of admission.

	Number of days to complete 33% of surgeries (99% CI)			Number of days to complete 66% of surgeries (99% CI)			Number of days to complete 90% of surgeries (99% CI)		
Province	Crude	Adjusted*†	Difference*†	Crude	Adjusted*†	Difference*†	Crude	Adjusted*†	Difference*†
Early weekday admissions									
ON	1 (1, 1)	1 (1, 1)	referent	2 (2, 2)	2 (2, 2)	referent	4 (4, 4)	4 (4, 4)	referent
AB	1 (1, 1)	1 (1, 1)	0 (0, 0)	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 4)	3 (3, 3)	-1 (-1, -1)‡
BC	1 (1, 2)	1 (1, 1)	0 (0, 0)	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	-1 (-1, -1)‡
MB	2 (2, 2)	2 (1, 2)	1 (0, 1)‡	2 (2, 2)	2 (2, 2)	0 (0, 0)	4 (4, 5)	4 (4, 4)	0 (0, 0)
NB	1 (1, 1)	1 (1, 1)	0 (0, 0)	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 4)	4 (3, 4)	0 (-1, 0)
NL	1 (1, 2)	2 (1, 2)	1 (0, 1)‡	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 4)	4 (3, 4)	0 (-1, 0)
NS	1 (1, 1)	1 (1, 1)	0 (0, 0)	2 (2, 2)	2 (2, 2)	0 (0, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
PE	1 (1, 1)	1 (1, 1)	0 (0, 0)	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 4)	4 (3, 4)	0 (-1, 0)
SK	2 (2, 2)	2 (2, 2)	1 (1, 1)‡	3 (2, 3)	2 (2, 3)	0 (0, 1)	4 (4, 5)	4 (4, 4)	0 (0, 0)
Late weekday admissions									
ON	2 (2, 2)	2 (2, 2)	referent	3 (3, 3)	3 (3, 3)	referent	4 (4, 4)	4 (4, 4)	referent
AB	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
BC	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
MB	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	4 (4, 5)	4 (4, 5)	0 (0, 1)
NB	2 (2, 2)	2 (2, 2)	0 (0, 0)	2 (2, 3)	3 (3, 3)	0 (0, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
NL	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
NS	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	4 (4, 4)	4 (4, 5)	0 (0, 1)
PE	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	4 (4, 4)	4 (4, 5)	0 (0, 1)
SK	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	0 (0, 0)	5 (4, 5)	4 (4, 5)	0 (0, 1)
Weekend admissions									
ON	2 (2, 2)	2 (2, 2)	referent	2 (2, 2)	2 (2, 2)	referent	4 (4, 4)	4 (4, 4)	referent
AB	2 (2, 2)	2 (2, 2)	0 (0, 0)	2 (2, 3)	2 (2, 2)	0 (0, 0)	4 (4, 4)	4 (3, 4)	0 (-1, 0)
BC	2 (2, 2)	2 (2, 2)	0 (0, 0)	2 (2, 2)	2 (2, 2)	0 (0, 0)	4 (3, 4)	4 (4, 4)	0 (-1, 0)
MB	2 (2, 2)	2 (2, 2)	0 (0, 0)	2 (2, 2)	2 (2, 3)	0 (0, 1)	4 (4, 5)	4 (4, 4)	0 (0, 0)
NB	1 (1, 1)	1 (1, 2)	-1 (-1, 0)‡	2 (2, 2)	2 (2, 2)	0 (0, 0)	4 (3, 4)	4 (3, 4)	0 (-1, 0)
NL	2 (2, 2)	2 (2, 2)	0 (0, 0)	2 (2, 3)	3 (2, 3)	1 (0, 1)‡	4 (3, 4)	4 (4, 4)	0 (0, 0)
NS	1 (1, 1)	1 (1, 1)	-1 (-1, -1)‡	2 (2, 2)	2 (2, 2)	0 (0, 0)	4 (4, 4)	4 (4, 4)	0 (0, 0)
PE	1 (1, 1)	1 (1, 2)	-1 (-1, 0)‡	2 (2, 2)	2 (2, 2)	0 (0, 0)	4 (3, 4)	4 (3, 4)	0 (-1, 0)
SK	2 (2, 2)	2 (2, 2)	0 (0, 0)	3 (3, 3)	3 (3, 3)	1 (1, 1)‡	4 (4, 5)	4 (4, 4)	0 (0, 0)

Provinces defined in Table1; CI = confidence interval

*Standardized for distribution of age, sex, pre-fracture health status, hospital volume, admission status, demand, transfer history, pre-operative procedures, fracture type, type of surgery, and calendar year of surgery for Ontario

†Excludes 81 patients with unknown sex or timing of admission

‡Statistically significant on the magnified scale and clinically significant on the original day scale

Section 6.2: Late weekday admissions

Among late weekday admissions, 44,895 (83.9%) hip fracture surgeries were completed within three inpatient days. This proportion varied across provinces from a low of 78.8% in Saskatchewan to a high of 86.3% in British Columbia. After adjustment, Prince Edward Island completed 2.8% less surgeries within three inpatient days compared to Ontario (difference = -2.8; 95% CI -5.0, -0.6) (Table 4).

Among late weekday admissions, 4,786 (8.9%) hip fracture surgeries were completed on admission day. This proportion varied across provinces from a low of 4.2% in Saskatchewan to a high of 20.1% in New Brunswick. After adjustment, Prince Edward Island completed 5.0% more surgeries (difference = 5.0; 95% CI 2.9, 7.0), Alberta completed 3.2% less surgeries (difference = -3.2; 95% CI -6.2, -0.2), Manitoba completed 4.1% less surgeries (difference = -4.1; 95% CI -8.0, -0.2), and Saskatchewan completed 4.1% less surgeries (difference = -4.1; 95% CI -7.0, -1.2) on admission day compared to Ontario (Table 4).

Among late weekday admissions, the number of inpatient days required to complete 33% of hip fracture surgeries was two inpatient days for all provinces, while the number of inpatient days required to complete 66% and 90% of hip fracture surgeries ranged from two to three, and four to five inpatient days, respectively, across provinces (Figure 6). All provinces required three inpatient days to complete 66% of surgeries, except for New Brunswick, which required two inpatient days. All provinces required

four inpatient days to complete 90% of surgeries, except for Saskatchewan, which required five inpatient days. After adjustment, there was no difference in the number of inpatient days required to complete 33%, 66%, and 90% of surgeries between any province and Ontario (Table 5).

Section 6.3: Weekend admissions

Among weekend admissions, 34,334 (87.9%) hip fracture surgeries were completed within three inpatient days. This proportion varied across provinces from a low of 82.8% in Saskatchewan to a high of 89.8% in British Columbia. After adjustment, there was no difference in the proportion of surgeries completed within three inpatient days between any province and Ontario (Table 4).

Among weekend admissions, 10,073 (25.8%) hip fracture surgeries were completed on admission day. This proportion varied across provinces from a low of 14.0% in Saskatchewan to a high of 42.3% in Prince Edward Island. After adjustment, Prince Edward Island completed 10.1% more surgeries (difference = 10.1; 95% CI 6.7,13.5), Manitoba completed 9.5% less surgeries (difference = -9.5; 95% CI -15.3, -3.7), and Saskatchewan completed 11.1% less surgeries (difference = -11.1; 95% CI -15.9, -6.3) on admission day compared to Ontario (Table 4).

Among weekend admissions, the number of inpatient days required to complete 90% of hip fracture surgeries was four inpatient days for all provinces, while the number of inpatient days required to complete 33% and 66% of hip fracture surgeries ranged

from one to two and two to three inpatient days, respectively, across provinces (Figure 6). All provinces required two inpatient days to complete 33% of surgeries, except for Prince Edward Island, New Brunswick, and Nova Scotia, which required one inpatient day. All provinces required two inpatient days to complete 66% of surgeries, except for Saskatchewan, which required three inpatient days. After adjustment, there was no difference in the number of inpatient days required to complete 90% of surgeries between any province and Ontario, while the number of inpatient days required to complete 33% of surgeries was one day shorter in New Brunswick, Nova Scotia, and Prince Edward Island compared to Ontario, and the number of inpatient days required to complete 66% of surgeries was one day longer in Saskatchewan and Newfoundland and Labrador compared to Ontario (Table 5).

Section 6.4: Patients treated with hip arthroplasty

Among patients treated with hip arthroplasty, 47,878 (85.5%) surgeries were completed within three inpatient days. This proportion varied across provinces from a low of 79.6% in Saskatchewan to a high of 88.9% in New Brunswick. After adjustment, there was no difference in the proportion of surgeries completed within three inpatient days between any province and Ontario (Table 6).

Among patients treated with hip arthroplasty, 11,913 (21.3%) surgeries were completed on admission day. This proportion varied across provinces from a low of 11.0% in Saskatchewan to a high of 35.9% in Prince Edward Island. After adjustment, Prince Edward Island completed 9.3% more surgeries (difference = 9.3; 95% CI 6.6,

12.0), Manitoba completed 5.3% less surgeries (difference = -5.3; 95% CI -10.1, -0.5), and Saskatchewan completed 8.0% less surgeries (difference = -8.0; 95% CI -12.1, -3.9) on admission day compared to Ontario (Table 6).

Table 6. The number and percentage of surgeries completed on admission day and within three inpatient days among hip fracture patients in Canada, excluding Quebec, between 2004 and 2012, by type of surgery.

	Total	Admission day			Within three inpatient days		
Province	No. of surgeries	No. of surgeries	Percentage of surgeries	Difference in % (95% CI) *†	No. of surgeries	Percentage of surgeries	Difference in % (95% CI) *†
Patients treated with hip arthroplasty							
ON	27,010	5,965	22.1	referent	23,083	85.5	referent
AB	6,404	1,190	18.6	-1.2 (-5.8, 3.3)	5,501	85.9	1.4 (-2.4, 5.1)
BC	10,266	2,052	20.0	-1.4 (-5.2, 2.5)	8,964	87.3	1.9 (-1.2, 4.9)
MB	2,853	442	15.5	-5.3 (-10.1, -0.5)	2,369	83.0	-2.1 (-7.7, 3.4)
NB	2,162	692	32.0	3.5 (-2.6, 9.6)	1,923	88.9	0.2 (-3.2, 3.5)
NL	1,337	293	21.9	-1.4 (-8.7, 5.9)	1,159	86.7	-0.5 (-2.5, 1.6)
NS	2,501	773	30.9	7.4 (-6.0, 20.8)	2,069	82.7	-4.6 (-19.1, 9.9)
PE	499	179	35.9	9.3 (6.6, 12.0)	435	87.2	-1.4 (-3.3, 0.5)
SK	2,985	327	11.0	-8.0 (-12.1, -3.9)	2,375	79.6	-4.2 (-12.5, 4.0)
Patients treated with internal fixation							
ON	40,612	10,296	25.4	referent	35,601	87.7	referent
AB	8,997	1,886	21.0	-1.7 (-7.1, 3.7)	7,998	88.9	2.2 (-0.7, 5.2)
BC	16,687	3,761	22.5	-2.1 (-6.7, 2.6)	15,055	90.2	2.7 (-0.1, 5.4)
MB	4,905	873	17.8	-7.0 (-13.5, -0.6)	4,160	84.8	-2.8 (-7.2, 1.6)
NB	2,656	971	36.6	3.7 (-4.8, 12.2)	2,349	88.5	-2.4 (-5.8, 0.9)
NL	1,845	455	24.7	-2.0 (-12.4, 8.4)	1,647	89.3	0.2 (-2.0, 2.3)
NS	3,538	1,144	32.3	5.9 (-7.1, 18.8)	3,044	86.0	-3.1 (-13.6, 7.5)
PE	536	187	34.9	4.8 (1.7, 7.9)	478	89.2	-0.8 (-2.4, 0.8)
SK	4,442	635	14.3	-7.5 (-13.1, -1.9)	3,657	82.3	-3.1 (-10.4, 4.3)

Provinces defined in Table 1; CI = confidence interval
*Standardized for distribution of age, sex, pre-fracture health status, hospital volume, timing of admission, admission status, demand, transfer history, pre-operative procedures, fracture type, and calendar year of surgery for Ontario
†Excludes 81 patients with unknown sex or timing of admission

Among patients treated with hip arthroplasty, the number of inpatient days required to complete 33%, 66%, and 90% of surgeries ranged from one to two, two to three, and four to five inpatient days, respectively (Figure 6). All provinces required two inpatient days to complete 33% of surgeries, except for Prince Edward Island, which required one inpatient day. All provinces required three inpatient days to complete 66% of surgeries, except for Prince Edward Island and New Brunswick, which required two

inpatient days. All provinces required four inpatient days to complete 90% of surgeries, except for Saskatchewan, which required five inpatient days. After adjustment, there was no difference in the number of inpatient days required to complete 33%, 66%, and 90% of surgeries between any province and Ontario (Table 7).

Table 7. The number of inpatient days required to complete 33%, 66%, and 90% of surgeries among hip fracture patients in Canada, excluding Quebec, between 2004 and 2012, by type of surgery.

	Number of days to complete 33% of surgeries (99% CI)			Number of days to complete 66% of surgeries (99% CI)			Number of days to complete 90% of surgeries (99% CI)		
Province	Crude	Adjusted*†	Difference*†	Crude	Adjusted*†	Difference*†	Crude	Adjusted*†	Difference*†
Patients treated with hip arthroplasty									
ON	2 (2,2)	2 (2,2)	referent	3 (3,3)	3 (3,3)	referent	4 (4,4)	4 (4,4)	referent
AB	2 (2,2)	2 (2,2)	0 (0,0)	3 (3,3)	3 (2,3)	0 (-1,0)	4 (4,4)	4 (4,4)	0 (0,0)
BC	2 (2,2)	2 (2,2)	0 (0,0)	3 (3,3)	3 (3,3)	0 (0,0)	4 (4,4)	4 (4,4)	0 (0,0)
MB	2 (2,2)	2 (2,2)	0 (0,0)	3 (3,3)	3 (3,3)	0 (0,0)	4 (4,5)	4 (4,5)	0 (0,1)
NB	2 (1,2)	2 (2,2)	0 (0,0)	2 (2,2)	3 (2,3)	0 (-1,0)	4 (3,4)	4 (4,4)	0 (0,0)
NL	2 (2,2)	2 (2,2)	0 (0,0)	3 (3,3)	3 (3,3)	0 (0,0)	4 (4,4)	4 (4,4)	0 (0,0)
NS	2 (1,2)	2 (2,2)	0 (0,0)	3 (2,3)	3 (3,3)	0 (0,0)	4 (4,5)	4 (4,5)	0 (0,1)
PE	1 (1,2)	2 (1,2)	0 (-1,0)	2 (2,3)	3 (2,3)	0 (-1,0)	4 (3,4)	4 (4,4)	0 (0,0)
SK	2 (2,2)	2 (2,2)	0 (0,0)	3 (3,3)	3 (3,3)	0 (0,0)	5 (4,5)	4 (4,5)	0 (0,1)
Patients treated with internal fixation									
ON	2 (2,2)	2 (2,2)	referent	2 (2,2)	2 (2,3)	referent	4 (4,4)	4 (4,4)	referent
AB	2 (2,2)	2 (2,2)	0 (0,0)	2 (2,3)	2 (2,2)	0 (0,0)	4 (4,4)	3 (3,4)	-1 (-1,0)‡
BC	2 (2,2)	2 (2,2)	0 (0,0)	2 (2,2)	2 (2,2)	0 (0,0)	3 (3,4)	4 (3,4)	0 (-1,0)
MB	2 (2,2)	2 (2,2)	0 (0,0)	3 (2,3)	3 (3,3)	1 (1,1)‡	4 (4,4)	4 (4,4)	0 (0,0)
NB	1 (1,1)	2 (2,2)	0 (0,0)	2 (2,2)	2 (2,3)	0 (0,1)	4 (4,4)	4 (4,4)	0 (0,0)
NL	2 (2,2)	2 (2,2)	0 (0,0)	2 (2,3)	3 (2,3)	1 (0,1)	4 (3,4)	4 (4,4)	0 (0,0)
NS	2 (1,2)	2 (2,2)	0 (0,0)	2 (2,2)	2 (2,3)	0 (0,1)	4 (4,4)	4 (4,4)	0 (0,0)
PE	1 (1,2)	2 (1,2)	0 (-1,0)	2 (2,3)	2 (2,3)	0 (0,1)	4 (3,4)	4 (3,4)	0 (-1,0)
SK	2 (2,2)	2 (2,2)	0 (0,0)	3 (3,3)	3 (3,3)	1 (1,1)‡	4 (4,4)	4 (4,4)	0 (0,0)

Provinces defined in Table 1; CI = confidence interval
*Standardized for distribution of age, sex, pre-fracture health status, hospital volume, timing of admission, admission status, demand, transfer history, pre-operative procedures, fracture type, and calendar year of surgery for Ontario
†Excludes 81 patients with unknown sex or timing of admission
‡Statistically significant on the magnified scale and clinically significant on the original day scale

Section 6.5: Patients treated with internal fixation

Among patients treated with internal fixation, 73,989 (87.9%) surgeries were completed within three inpatient days. This proportion varied across provinces from a low of 82.3% in Saskatchewan to a high of 90.2% in British Columbia. After adjustment,

there was no difference in the proportion of surgeries completed within three inpatient days between any province and Ontario (Table 6).

Among patients treated with internal fixation, 20,208 (24.0%) surgeries were completed on admission day. This proportion varied across provinces from a low of 14.3% in Saskatchewan to a high of 36.6% in New Brunswick. After adjustment, Prince Edward Island completed 4.8% more surgeries (difference = 4.8; 95% CI 1.7, 7.9), Manitoba completed 7.0% less surgeries (difference = -7.0; 95% CI -13.5, -0.6), and Saskatchewan completed 7.5% less surgeries (difference = -7.5; 95% CI -13.1, -1.9) on admission day compared to Ontario (Table 6).

Among patients treated with internal fixation, the number of inpatient days required to complete 33%, 66%, and 90% of surgeries ranged from one to two, two to three, and three to four inpatient days, respectively (Figure 6). All provinces required two inpatient days to complete 33% of surgeries, except for Prince Edward Island and New Brunswick, which required one inpatient day. All provinces required two inpatient days to complete 66% of surgeries, except for Manitoba and Saskatchewan, which required three inpatient days. All provinces required four inpatient days to complete 90% of surgeries, except for British Columbia, which required three inpatient days. After adjustment, there was no difference in the number of inpatient days required to complete 33% of surgeries between any province and Ontario, while the number of inpatient days required to perform 66% of surgeries was one day longer in Manitoba and Saskatchewan

compared to Ontario, and the number of inpatient days required to complete 90% of surgeries was one day shorter in Alberta compared to Ontario (Table 7).

Chapter 7: Discussion

Section 7.1: Main findings

Among surgically fit patients, the proportion of surgeries completed within three inpatient days was similar across provinces after adjusting for patient and system characteristics. All provinces required four inpatient days to complete 90% of surgeries. Provinces differed in the proportion of patients treated on admission day and in the number of inpatient days required to complete 66% of surgeries after adjustment for patient and system characteristics. Provincial variation in time to surgery differed across quantiles of time to surgery overall, by timing of admission, and by type of surgery. Provinces varied in the proportion of patients treated on admission day and in the number of inpatient days required to complete 33% and 66% of surgeries by timing of admission and by type of surgery.

Section 7.2: Comparison with other literature

Our results support and build upon the CIHI's provincial time to hip fracture surgery reporting. The CIHI's reports include all surgically treated patients (20,27,34,35). However, patients who are delayed for medical reasons may benefit from longer time to surgery (45,46,120). To build upon the CIHI reporting, we excluded patients with medically necessary delays. Similar to the CIHI's reporting, we found that the crude proportion of patients treated within the time to surgery benchmark varied across provinces. Between 2005 and 2006, 2006 and 2007, 2007 and 2008, and 2008 and 2009, the CIHI reported that the proportion of patients treated within three inpatient days ranged from 75.4% in Manitoba to 89.8% in British Columbia, 76.3% in Manitoba to

89.5% in British Columbia, 73.8% in Saskatchewan to 89.3% in British Columbia, and 72.2% in Saskatchewan to 88.2% in Newfoundland and Labrador, respectively. Between 2004 and 2012, we report that the proportion of patients treated within three inpatient days ranged from 81.2% in Saskatchewan to 89.1% in British Columbia (76). Variation across provinces in the proportion of patients treated within three inpatient days appears to decrease after excluding patients with medically necessary delays. To further improve upon the CIHI's estimates of provincial variation in time to surgery, we estimate provincial differences in time to surgery while adjusting for patient and system characteristics. The provincial variation in the proportion of patients treated within the benchmark decreases after adjusting for patient and system characteristics. This indicates that some of the observed provincial variation in the proportion of patients treated within the benchmark is due to differences across provinces in the characteristics of the patient populations and of the systems that deliver their care.

The time to surgery benchmark for hip fracture was set at the national level, however, no guidance was provided to the provinces on how it should be implemented. We found that there were provincial differences in the proportion of surgeries completed on admission day, overall, by timing of admission, and by type of surgery. In addition, the number of inpatient days required to complete 33% and 66% of surgeries differed across provinces. Yet, provinces provided similar access to surgery within the time to surgery benchmark. These findings may be indicative of differences in how hip fracture surgery is prioritized at various decision making levels and the efforts of provinces to

work within their existing health care structures to implement processes to ensure patients are treated within the recommended time (42).

Prioritisation of hip fracture surgery may vary between provinces due to differences in the availability and demand for resources (36,103). In Canada, there are no national standardized categories of surgical prioritization. Furthermore, not all hospitals offer all surgical specialities, and therefore hip fracture patients may compete with different surgical specialties for access to surgical resources (121). As a result, hospitals may prioritize hip fracture surgery differently depending on the competing demands for OR time and resources. We found that the number of inpatient days required to complete 66% of surgeries was one day shorter in British Columbia, Alberta, and New Brunswick compared to Ontario. Hip fracture patients treated in hospitals with large volumes of emergent and urgent surgeries are frequently underprioritized and delayed beyond the recommend time to surgery. In response, some hospitals have instituted a policy of automatically updating the priority classification of hip fracture cases the following inpatient day or 24 hours after admission (122). For instance, a teaching hospital in British Columbia automatically updates the priority classification of hip fracture patients the inpatient day after admission to ensure that patients receive surgery within two inpatient days (123). Updating the priority classification of patients the inpatient day or 24 hours after admission promotes early access to surgery and may prevent patients being delayed beyond the benchmark time to surgery.

The length of preoperative inter-hospital transfer may vary between provinces due to differences in the physical distance between hospitals. We found that Manitoba and Saskatchewan completed fewer hip fracture surgeries on admission day when compared to Ontario. In Ontario, a large proportion of the population has direct access to tertiary care centers. In Manitoba and Saskatchewan, tertiary care centers are located in southern cities that are not immediately accessible to some segments of the population (124). Patients in Manitoba and Saskatchewan that require a transfer to a tertiary care center may have to travel longer distances for surgery. As a result, these patients may be admitted later in the day and have to wait for resources to become available for surgery (76).

The association between the day of admission and time to hip fracture surgery has been inconsistent in the literature (50,97-103). We examined three subgroups of patients defined by their timing of admission: patients admitted early on a weekday, late on a weekday, and on the weekend. We identified differences in access to surgery by timing of admission. A larger proportion of surgeries were completed on admission day when patients were admitted early on a weekday (36.2%) than when patients were admitted late on a weekday (8.9%), or on a weekend (25.8%). Studies from Canada, the United States, and Australia report that approximately 25% of all patients are treated on the day of admission (99,101,125). However, our findings indicate that access to surgery on admission day for patients admitted on a weekday differs by the timing of admission. Previous studies by Zeltzer et al. and Nijland et al. found that patients admitted during the week were more likely to be delayed to surgery when compared to patients admitted on a

weekend, while studies by Fantini et al. and Ryan et al. found that patients admitted on the weekend were more likely to be delayed to surgery than patients admitted during the week (98,99,101,102). However, these studies did not account for differences in the timing of admission. The inconsistent results may be due to the greater chance for patients admitted early during the day on a weekday to undergo surgery on admission day than patients admitted in the afternoon or evening.

Access to resources may differ across provinces by timing of admission. We found that provincial variation in access to hip fracture surgery differed across timing of admission subgroups. Among weekend admissions, the number of inpatient days required to complete 66% of surgeries was one day more in Newfoundland and Labrador compared to Ontario, while among early weekday admissions, there was no difference in the number of inpatient days required to complete 66% of surgeries between Newfoundland and Labrador and Ontario. Among late weekday admissions, Alberta treated a smaller proportion of patients on admission day compared to Ontario, however, among early weekday admissions, there was no difference in the proportion of patients treated on admission day between Alberta and Ontario. Lack of availability of the OR is frequently cited as a reason for delay to surgery (49,50). The working hours of ORs vary across hospitals. In three teaching hospitals in Canada, the working hours of different ORs ranged from 07:00 to 23:00, 07:00 to 17:00, 08:00 to 16:00, and 08:00 to 23:00 (123,126,127). One of the hospitals opened an additional OR on Thursday to clear the queue of patients before the weekend and on Monday to help alleviate the queue from the weekend (126). Provinces and health care regions may have different OR policies

concerning when hip fracture surgery may be performed. Some may only allow emergency surgeries to be performed after-hours and on the weekends.

Consistent with other studies, we observed a longer delay for patients undergoing hip arthroplasty than internal fixation (98,101,104,128). Approximately 40% of patients were treated with hip arthroplasty, and this percentage was stable over the study period (less than 1% range). This finding is supported by the literature, as Pincus et al. reported that 39% of patients were treated with hip arthroplasty in Ontario (26). The available data did not distinguish between the two types of hip arthroplasty procedures, specifically total hip arthroplasty and hemiarthroplasty. However, in Canada, the clear majority of hip fractures patients treated with arthroplasty are treated with hemiarthroplasty as opposed to total hip arthroplasty (129).

While investigators from other jurisdictions have identified a number of potential reasons why patients undergoing hip arthroplasty have longer delays, it is not possible to state with certainty which of these was occurring in the Canadian provinces over the study period. First, investigators in Australia highlight that patients treated with hip arthroplasty may have a longer time to surgery due to delays acquiring the prostheses required for the procedure (101). Second, the complexity of hip arthroplasty means orthopedic surgeons require specific training beyond that required for internal fixation; as both the acetabulum and the head of the femur are replaced in total hip arthroplasty, it is more complex than hemiarthroplasty in which only the head of the femur is replaced (52). Consequently, while patients treated with hemiarthroplasty are not typically delayed to

surgery due to surgical expertise, patients treated with total hip arthroplasty may be delayed to surgery due to the availability of sufficiently experienced surgeons. Third, the duration of surgery is longer for hip arthroplasty than internal fixation (and the duration of surgery is longer for total hip arthroplasty than hemiarthroplasty) (52,130). It could be that patients need to be delayed longer to be properly stabilized or there could be additional challenges associated with scheduling a longer procedure with constrained OR time. While several possible explanations have been put forth to explain the greater delay to surgery observed among patients treated with hip arthroplasty, the specifics of how type of surgery affects time to surgery remain unclear. Studying any of these issues would require, at the very least, distinguishing between total hip arthroplasty and hemiarthroplasty in the hospital discharge data.

Access to resources may differ across provinces by type of surgery. We found that among patients treated with hip arthroplasty, Manitoba and Saskatchewan treated a smaller proportion of patients on admission day compared to Ontario. In our study, the subgroup of patients treated with hip arthroplasty includes patients treated with total hip arthroplasty and hemiarthroplasty. Total hip arthroplasty is a particularly complex procedure that requires additional resources for surgery. Compared to hemiarthroplasty, the procedure has been associated with increased delay to surgery (101). Wide disparities in utilization of total hip arthroplasty have been reported in the literature. For instance, Perry et al. observed that patients admitted on the weekend were less likely to receive total hip arthroplasty (51). We found that Ontario treated a relatively large proportion of patients admitted on the weekend, while Manitoba and Saskatchewan treated a relatively

small proportion of patients admitted on the weekend. As a result, more patients in Manitoba and Saskatchewan may have been treated with total hip arthroplasty and had to wait for resources to become available for surgery. The use of total hip arthroplasty and the associated additional delay to surgery may vary across provinces for a variety of reasons, including access to sufficiently experienced surgeons.

Advocates for early hip fracture surgery contend that patients should be treated within 24 hours from admission (103,131). To address the provincial variation in the proportion of patients treated on admission day and in the number of days required to complete 33% and 66% of surgeries overall, by timing of admission, and by type of surgery, hospital administrators and provincial public health officials may wish to develop and implement processes to improve early access to surgery. Many hospitals complete the scheduled elective procedures before performing urgent procedures. One policy option to improve early access to surgery is to guarantee that the scheduled elective procedures will be completed each day. This would allow for the prioritization and scheduling of urgent procedures early in the day, potentially improving early access to hip fracture surgery (26). In addition, dedicating an OR to emergent and urgent procedures may improve time to surgery for patients admitted late in the day or on the weekend (84). Early identification of patients eligible for total hip arthroplasty and improving access to the resource necessary for this complex surgery may improve early access to surgery for patients treated with this procedure. Processes to improve early access to surgery should be evaluated for their effect on patient outcomes, hospital resources, and cost. The evaluation must consider the fact that hip fracture surgery is

prioritized among other important emergent, urgent, and elective procedures and that resource capacity is finite (84,85).

Chapter 8: Strengths and Limitations

The main strength of this study is the improved estimation of provincial variation in time to hip fracture surgery in Canada. We excluded all patients who were not fit for surgery using a screening algorithm developed by the CCHF (110). By excluding these patients, we removed any provincial variation in time to surgery that may have been due to patients being delayed to surgery out of medical necessity. In addition, while previous reports of provincial variation reported time to surgery by province and either did not adjust for covariate differences between provinces or adjusted only for age, sex, and selected comorbidities, we estimated provincial differences in time to surgery while adjusting for a range of patient and system characteristics known to affect time to surgery (70,105).

Another strength of this study is the novel use of quantile regression to investigate provincial variation in time to surgery at various quantiles of time to surgery. Provincial variation in time to surgery may be different at different points on the time to surgery distribution. In addition, the effect of patient and system characteristics on time to surgery may be different at different points on the time to surgery distribution. The use of quantile regression to estimate provincial differences in time to hip fracture surgery at various quantiles of time to surgery while accounting for differences in patient and system characteristics allowed us to identify differences in provincial variation at different points on the time to surgery distribution.

The study is also strengthened through the exploration of potential mechanisms that underlie the observed provincial variation in time to hip fracture surgery. Several characteristics of our study allowed us to explore these mechanisms. We examined five different measures of time to surgery that represent different points on the time to surgery distribution. We examined the crude provincial variation in time to surgery after excluding patients not fit for surgery. We examined provincial differences in time to surgery after adjusting for patient and system characteristics known to affect time to surgery. Finally, we examined provincial variation in time to surgery among subgroups of surgically fit patients admitted early on weekday, late on a weekday, and on a weekend and among patients treated with hip arthroplasty and internal fixation.

Another strength of this study is its scope. The study is population-based, including all hip fracture patients, 65 years or older, who were treated in Canadian acute care facilities, excluding Quebec, between 2004 and 2012. The study also benefits in efficiency from the previous work done by the CCHF in extracting data from the CIHI DAD, constructing the analytical dataset, and creating the screening algorithm used to identify patients not fit for surgery. Finally, the study is strengthened through the dissemination of the results in the literature. One article has been published in *Osteoporosis International* (47) and another article is being developed for publication.

The study is limited by the number and nature of the variables available for covariate adjustment. Hospital discharge abstracts, originally collected for administrative purposes, are used in this study. There is limited clinical information available in the

discharge records. For instance, the data does not capture if a patient received a preoperative internal medicine consult, which may be required if a patient presents with polypharmacy and comorbidities. In addition, detailed information on the system delivering the health care services is not available. For instance, there is no data on the availability of surgical staff or OR time.

The study may have overestimated the number of surgically fit hip fracture patients. To identify patients fit for surgery, we exclude patients with an admission to an intensive care unit or a step-down unit or with conditions that the NICE identifies as a medically necessary reason for delay to surgery. However, these conditions are not exhaustive, there are other conditions, such as gastrointestinal hemorrhage or uncontrolled hypertension, that may justify a delay to surgery (45). By overestimating the number of surgically fit patients, we may have overestimated delay. It is possible that overestimating the number of surgically fit patients has systematically biased our results. For instance, provinces with a larger number of older patients would likely have had more patients with uncontrolled hypertension and therefore may have had more patients with medically necessary delays. However, there are likely a small number of patients with these conditions, and therefore we do not believe that it affected our results. While we restricted our exclusions to conditions that the NICE identifies as a medical reason for delay, future studies of provincial variation in time to surgery may wish to expand upon this list to include other conditions that justify a medical delay.

The length of the study period is also a limitation. We examined all hip fracture patients, 65 years or older, who were treated in Canadian acute care facilities, excluding Quebec, between 2004 and 2012. In our study, we estimate provincial differences in time to surgery and we adjust for the patient and system characteristics of each province over the study period. However, patient and system characteristics of the provinces may have varied over the study period. Prince Edward Island may be particularly susceptible to this variation as there is only one hospital that performs hip fracture surgery in the province. As a result, there may be smaller periods of time where the provincial variation in time to surgery may be different from the provincial variation we reported over the full study period. Our study provides an overview of provincial variation in time to surgery between 2004 and 2012. Future studies of provincial variation in time to surgery may wish to restrict their analysis to periods of time where patient and system characteristics are likely to be stable.

The study is limited in its generalizability. Patients who underwent hip fracture surgery in a hospital with an annual surgical volume of less than 24 surgeries are excluded in our study. As a result, we excluded 146 patients who were surgically treated in the Yukon, the Northwest Territories, and Nunavut. In addition, the CIHI DAD does not include data from Quebec (21). Therefore, the findings may not be applicable to Quebec, the Yukon, Northwest Territories, or Nunavut.

Chapter 9: Future Research

Advocates for early hip fracture surgery contend that patients should be treated within 24 hours from admission (103,131). We found that provinces varied in the proportion of surgeries completed on admission day, overall, by timing of admission, and by type of surgery. Understanding what characteristics contribute to this variation may assist provinces in optimizing the path from admission to surgery. For instance, examining how transfer times vary across provinces and the different provincial policies that address the prioritisation of transferred patients may present opportunities to improve time to surgery.

In some provinces, the administration and delivery of health care services are organized regionally (132). We found that there were no differences across provinces in the proportion of hip fracture surgeries completed within the time to surgery benchmark. However, variation may exist across health care regions. Indeed, waiting time for some priority procedures has been observed to vary across health care regions within provinces (29). Future research should examine whether time to hip fracture surgery varies across health care regions, among surgically fit patients, to determine if there is an unmet need. In addition, an effort should be made to identify the extent to which patient and system characteristics contribute to regional variation in time to surgery (47).

Not all types of hip fractures are amenable to all surgical procedures. Internal fixation may be used to treat transcervical fractures, intertrochanteric fractures, or subtrochanteric fractures. However, total hip arthroplasty and hemiarthroplasty are only

used to treat transcervical fractures (15,16). In the current study, the proportion of patients treated on admission day and within three inpatient days was higher among patients treated with internal fixation than patients treated hemiarthroplasty or total hip arthroplasty. Total hip arthroplasty is a more complex surgery than hemiarthroplasty and has been associated with increased delay to surgery (58,101). Future research may seek to investigate how time to surgery differs between patients treated with total hip arthroplasty and hemiarthroplasty among patients who sustained a transcervical fracture. This may be of particular interest given the growing trend to treat transcervical fractures with total hip arthroplasty rather than hemiarthroplasty among younger more mobile patients (15,58).

We observed variation in time to hip fracture surgery across provinces for subgroups of patients defined by their timing of admission and type of surgery. Future research should establish if this variation affects the utilization of resources, costs, and the rates of postoperative mortality, complications, and morbidity.

Chapter 10: Conclusion

The provision of equitable and timely access to hip fracture surgery is a major undertaking of the Canadian public health system. In 2005, Canada established a benchmark time to surgery of 48 hours from admission for 90% of hip fracture patients (19,20). However, to this day most provinces are not meeting the benchmark and provincial variation in time to surgery has persisted since the establishment of the benchmark (27). The observed variation may reflect inequity in access to care and an underuse of early surgery.

To determine if early surgery is being underused in the Canadian provinces and to provide insight into the extent to which patient and system characteristics contribute to the observed provincial variation in time to surgery, we sought to answer four study questions:

1) Does time to hip fracture surgery vary across provinces among surgically fit patients after adjusting for patient and system characteristics?
2) Is the provincial variation in time to hip fracture surgery consistent across various quantiles of time to surgery?
3) Does time to surgery vary across provinces among patients admitted early on a weekday, late on a weekday, and on a weekend, respectively?
4) Does time to surgery vary across provinces among patients treated with hip arthroplasty and internal fixation, respectively?

Among surgically fit patients, the proportion of surgeries completed within three inpatient days was similar across provinces after adjusting for patient and system characteristics. All provinces required four inpatient days to complete 90% of surgeries. Provinces differed in the proportion of patients treated on admission day and in the number of inpatient days required to complete 66% of surgeries after adjustment for patient and system characteristics. Provincial variation differed across quantiles of time to surgery overall, by timing of admission, and by type of surgery. Provinces varied in the proportion of patients treated on admission day and in the number of inpatient days required to complete 33% and 66% of surgeries by timing of admission and by type of surgery.

The results have several important implications for public health. While provinces performed similarly with respect to the time to surgery benchmark, no province completed 90% of surgeries within the recommended three inpatient days. In other words, all provinces underused early surgery. The provincial variation in the proportion of patients treated on admission day and the number of inpatient days required to complete 33% and 66% of surgeries overall, by timing of admission, and by type of surgery may reflect differences in how hip fracture surgery is prioritized at various decision making levels and the efforts of provinces to work within their existing health care structures to implement processes to ensure patients are treated within the recommended time (42). Health care administrators and provincial public health officials may wish to study the processes employed by provinces that are treating a larger proportion of patients on admission day and are requiring fewer inpatient days to

complete 33% and 66% of surgeries. Before implementing any processes to improve access to early surgery, the processes should be carefully evaluated for their effect on patient outcomes, hospital resources, and cost, with the understanding that hip fracture surgery is prioritized among other important emergent, urgent, and elective procedures and that resource capacity is finite (84,85).

This study has improved the estimates of provincial variation in time to hip fracture surgery in Canada. We described the variation in time to surgery across provinces among surgically fit patients while accounting for differences in patient and system characteristics. In addition, we described the provincial variation in time to surgery among patients defined by their timing of admission and among patients defined by their type of surgery. We hope this study is informative to health care administrators and public health officials who are tasked with the difficult job of developing and implementing processes to treat hip fracture patients in a timely and equitable fashion.

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