CANADIAN PARTNERSHIP AGAINST CANCER
PARTENARIAT CANADIEN CONTRE LE CANCER

Approaches To High-Risk, Resource Intensive Cancer Surgical Care In Canada

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This document has been made possible through a financial contribution from Health Canada, through the Canadian Partnership Against Cancer.

ISBN 978-1-988000-04-6

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ACKNOWLEDGEMENTS

It is only through the contribution of many individuals and organizations that the production of this report was possible. We express our gratitude to the following for their contributions and assistance on this report:

Strategic Oversight provided by Canadian Partnership Against Cancer

Mary Argent-Katwala PhD
Canadian Partnership Against Cancer
Director, Diagnosis and Clinical Care

Terrence Sullivan PhD
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Consultations with Provincial Health Care Delivery Experts

We thank the following individuals for consenting to discuss the structure of cancer surgical care and healthcare services as a whole within their province. The feedback informed much of the descriptions in Chapter 5 and provided an understanding of the varied landscape of healthcare provision throughout Canada. Attempts were made to reach informants in Saskatchewan and PEI, but were unable to coordinate formal discussions

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Newfoundland and Labrador Alex Mathieson MD Assistant Professor of Surgery Memorial University, St. John's NL Eastern Health Disease Site Member	**National** Heather Logan Executive Director, Canadian Association of Provincial Cancer Agencies (CAPCA)

We thank the following individuals for their assistance with obtaining data or otherwise assisting the authorship team with gaining access to the vital information used in this project. We acknowledge that the analyses, conclusions, opinions and statements expressed herein are those of the authors and not those of CIHI, ICES, PopDataBC or the Canadian Cancer Society

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Institute for Clinical Evaluative Sciences (ICES) Refik Saskin MSc Staff Scientist, Data and Analytic Services Nadia Gunraj MPH Lead Analyst, Data & Analytic Services	**Population Data British Columbia (PopDataBC)** Monique Gagné Data Access Coordinator/Documentation

Canadian Cancer Society
Data from the Canadian Cancer Society was accessed from the National data reporting, and was utilized to assess population distributions

EXECUTIVE SUMMARY

PROJECT SCOPE

A principal objective of health care planners and administrators is to deliver care that maximizes patient outcomes while balancing patient safety, satisfaction and reasonable access to care. Cancer and associated care demands a tremendous burden on patients and on limited health care system resources. Increasingly, cancers are identified at earlier stages, positioning surgery as the optimal and often only chance for cure and/or management of the disease. While many patients fare well after surgery with no complications and are discharged home within expected timelines, some patients experience more complex post-surgical courses with extended length of stay and adverse events that require additional care, re-admission to hospital or ultimately death. Improving the outcomes of surgical care has the potential to save lives, reduce the burden of disease on patients and caregivers, and reduce health care costs.

There is tremendous variability in how each province in Canada delivers cancer care services, resulting in disparities in patient outcomes that necessitate attention. At least some of these disparities can be attributed to the low population density in Canada and the need to provide services in geographically disperse centers, where not all of which can provide highly specialized surgical resources. There is a special imperative in Canada as one of the least densely populated, but highly developed countries to articulate these issues. Surgical cancer care is facing particular challenges, with rising incidence rates for most cancers and an aging population increasing the demand for these surgeries. Certain cancer surgeries, such as those for esophageal, pancreatic, liver, lung and ovarian cancers, are particularly complex and are associated with a high risk of adverse outcomes, leading to an increased burden on health care resources. It is for this reason that this report focuses on deliberate strategies that aim to improve the organization of complex cancer surgeries in a way that enhances the quality of health care delivery. One approach that has gained considerable attention in the last two decades is the 'regionalization' of surgical care. There is no consensus on the precise definition of regionalization relative to the concept of consolidation of care to high volume centres. Whereas regionalization involves a deliberate re-organization of services, consolidation has occurred in some locations where centres are simply closed and patients receive care in an alternate institution. Based on the literature and expert opinion, the following working definition of regionalization was utilized in this report:

"the deliberate reorientation of cancer surgical procedures, based on explicit and planned processes and structures, with the intent of improving the quality of care"

This pan-Canadian report provides an objective analysis and discussion about the approach to high-risk, resource intensive cancer surgical procedures for esophageal, pancreatic, liver, lung and ovarian cancers in Canada. We intend to inform policy makers, health care planners and administrators on the current state of cancer surgical care and outcomes; highlight potential opportunities for improvement; and provide actionable recommendations to improve the quality of care for individuals and families bearing the burden of cancer.

METHODOLOGY

This report utilized various sources to inform a comprehensive discussion on the impact of regionalization on the quality of surgical cancer care delivery in Canada. A systematic review of the literature was conducted to ascertain the current understanding of the relationship between regionalization and outcomes. Structured interviews with provincial clinical experts (Acknowledgement section) established the state of care delivery processes implemented across Canada. Patient outcomes, access to care and travel times were evaluated across the country using quantitative analyses and validated Geographic Information System (GIS) techniques to objectively demonstrate how care consolidation impacts the clinical outcomes and patient experience. Finally, patient perspectives and expectations of cancer care delivery were captured from a series of citizen panels convened across three different provinces with varying health care delivery demands.

KEY FINDINGS

The literature provides evidence for the positive impact of regionalization on surgical cancer care

- The bulk of the literature and pan-Canadian evidence supports the regionalization of cancer care, based upon objective measures such as operative mortality and length of stay. This is often expressed as a volume-outcome relationship, where larger volume centres have better patient-centred outcomes.
- Institutional volume is regarded as the simplest and most robust metric for describing volume-outcome relationships. Other institutional and surgeon factors likely contribute to improved patient outcomes, although they are not well discussed in the literature and it is difficult to elucidate the effects of each of the elements individually given the multifactorial nature of care.
- There is no agreed upon volume threshold reported in the literature for any of the cancer types evaluated. Practically speaking, the volume-outcome effect is demonstrated even between institutions with high case volumes; this suggests that it would be imprudent to implement a single defined procedure volume threshold.

Higher volume centres predicted a significantly lower risk of in-hospital mortality and shorter length of stay in the Canadian experience

- A reduced risk of in-hospital mortality was significantly associated with an increase in hospital volume for esophageal, pancreatic, lung, and ovarian cancer resections; whereas higher facility volume predicted a shorter length of stay for all five types of cancer resections.
- The impact of hospital volume on the risk of in-hospital mortality was most pronounced for esophageal and pancreatic cancers. In a statistical model controlling for the influence of patient- and hospital-specific factors, every 10 case increase in hospital volume predicted a risk reduction of in-hospital mortality of 21% and 22% for esophageal and pancreatic cancer surgeries, respectively. The calculated risk reduction was 3% and 7% for lung and ovarian cancer surgeries, respectively.

There are significant disparities in patterns of practice and patient outcomes for surgical cancer care across Canada

- There is a tremendous variance in in-hospital mortality, resection rate, and length of stay outcomes of high-risk cancer surgical care across Canada.
  - In many of the surgeries evaluated, there was a three to four times difference in mortality rates between the provinces. This difference is most broadly demonstrated by the case of esophageal cancer, where patients in Newfoundland and Labrador saw a 2.72% mortality rate while those in Manitoba have an 11% risk of death. These results are both statistically and clinically significant, and are partly due to hospital and/or surgeon volumes. This indicates a need for provinces to thoroughly investigate their current practices and to consider implementing proven strategies that mitigate or reduce the disparities.
  - There are substantial differences between provinces relating to resection rates for all cancers studied but ovarian, with the likelihood of receiving a potentially curative operation in a province with high resection rates can be double that of provinces with lower rates. In the case of liver cancer, patients in New Brunswick have a 6.9/100,000 resection rate, while patients residing in Alberta would expect a 14/100,000 rate of resection. These differences between rates can be due to many different factors that will influence how many patients are suitable for surgery or whether surgical services are available in a given area. Provinces should examine the distribution of stage at presentation, patient co-morbidities, and the travel distances to care to determine if resection rates could be optimized by screening programs, rapid diagnostic workup via diagnostic assessment programs, referrals to high volume centres, or other quality improvement initiatives in order to reach ideal thresholds and improve patient survival.
  - The findings also report a large variance in the duration of hospital stay across the country, a fact that speaks to differences in the efficiency of the systems currently in place, or differing institutional policies. The length of stay can vary by 2-3 days (~20-30%) on average per patient depending on where the procedure is performed. Patients undergoing pancreatic cancer surgery demonstrate the widest difference, with the duration in hospital of Saskatchewan averaging 14 days while patients in Ontario can expect to stay 9 days. The reasons for this difference have yet to be elucidated, but may indicate differing rates of complications or surgical complexity undertaken depending on the experience and training of surgical teams. It is imperative that each province investigate causes of length of stay variance in order to improve the efficiencies of their respective systems.
  - The estimated hypothetical impact of surgical cancer care regionalization was considered by investigating the number of lives that could be potentially saved if all patients underwent surgery at the highest tertile volume centres, where they could expect the outcome rate demonstrated by the high volume tertile. An adjusted estimate of the potential number of lives saved is presented in Figure 1. When considering the proportion of potential lives saved relative to the number of deaths, highest gains are expected for pancreatic cancer surgeries (60%), followed by lung (30%) and ovarian (32%) cancer surgeries. These potential gains provide the impetuous to consider

regionalization approaches on a provincial level or policies that discourage single surgeons within a centre. Even in the highest volume centres, quality improvement measures such as the introduction of surgical standards, staff training or uptake of best practice operative techniques have the potential to further reduce mortality.

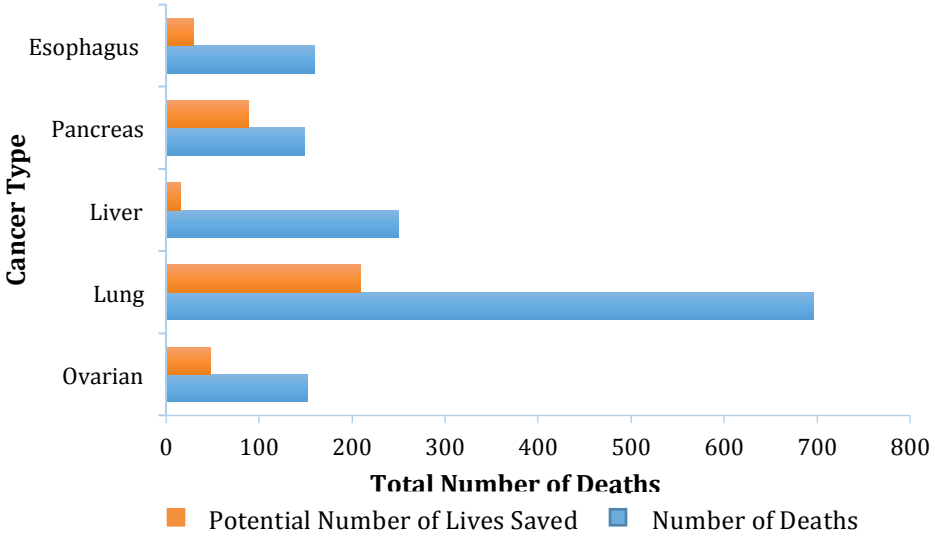


Figure 1: Potential number of lives saved through consolidation in high-volume centres

- In similar modelling, if all patients experienced the results of those in hospitals in the highest volume tertile, a total of 4775 hospital days annually could potentially have been saved. If all care was provided in high volume hospitals, 3335 hospital days associated with lung cancer cases, 308 days for liver cancer, 725 days with pancreatic cancer and 407 days with esophageal cancer surgeries would have been saved annually. The number of days could not reliably be determined for ovarian cancer surgeries.

There is a lack of a unified approach for the provision of surgical cancer care in Canada

- Despite the significant role of surgery in the cancer management pathway, cancer surgery management is largely not integrated under the umbrella of provincial cancer agencies. In most provinces, there are no explicit roles to oversee the systematic provision, evaluation and regulation of cancer surgery within a province. This results in a lack of accountability in most of the country and an inability to enact change or to initiate a formal process to track and evaluate outcomes.
- A thorough screening of the literature for relevant policy documents along with discussions with key stakeholders in each of the provinces revealed that there is a deficit of coordinated efforts at either a provincial or national level to improve quality of complex cancer surgeries across the country.
- In most provinces, there is minimal regulation as to which procedures surgeons or hospitals can or should perform within their specialty area, or how frequently they need to perform these procedures to ensure their surgical skills remain up to date.

There is a need for national clinical guidelines and standards for surgical cancer care

- Ontario has the most explicit regionalization policies and guidelines, with evidence of implementation for esophageal, lung, pancreatic, and liver cancer surgeries. Similar guidelines for ovarian cancer have been published, but implementation is still a work in progress at this time. Purposeful steps have been taken, although without published guidelines, to consolidate cancer surgery for certain disease sites in British Columbia (Thoracic and Gynecologic cancer surgery) and Manitoba. In the other provinces, specific policies and guidelines are either absent, unclear or unknown to the authors despite discussions with local stakeholders.

Ovarian cancer: Is there a case for regionalization?

- The large number of institutions delivering surgical care for patients with ovarian cancer indicates a cancer type that may benefit from regionalization policies that would bring patients requiring ovarian surgical cancer care to specialized higher volume centres. It has half the number of cases nationally as lung cancer, but three times the number of institutions performing these surgeries, with many of the centres reporting a very small total annual case volume. This may improve patient outcomes in a manner similar to that seen in other cancer types.

Regionalization has an impact on travel time to surgical services

- The median travel time varies greatly between provinces and is largely influenced by geography. Travel times slightly increased between 2004 and 2012 almost irrespective of patient location.
- Across all cancer sites, the proportion of patients who had to travel more than one hour to access care increased as the number of centres that provide surgical cancer services decreased. This data confirms that the regionalization of some services to high volume, central locations occurs at the expense of patient travel time.

Patients and Caregivers prefer better surgical care quality at the expense of longer travel distances

- Three citizen panels, with 38 participants in total, were conducted in Edmonton AB, Hamilton ON and Charlottetown PEI where participants emphasized a preference for high-quality surgical care rather than convenience.
- Participants emphasized on a strong need for the provision of a local support network to be available for patients and caregivers even in cases where cancer surgeries have been regionalized.
- Participants felt that a compromise of regionalizing surgical services while facilitating local pre- and post-operative clinical care or the utilization of telemedicine innovations may represent an optimal approach to regionalizing these complex cancer services in a way that is acceptable to the Canadian population.

KEY RECOMMENDATIONS

The significant variance in how surgical cancer care services are delivered between the provinces greatly impacts patient survival, efficiency of the healthcare system itself and how well patients can access care. In a prosperous country such as Canada, these disparities are unacceptable. While there are many theories for why these disparities are present, this report identified key issues that likely influence difference between the provinces. We reported significant gaps in knowledge that prevent informed decision making, a lack of surgical cancer care leadership within the continuum of cancer care, a lack of a standardized quality monitoring program, and finally minimal adoption of active regionalization policies that are likely to enact change. These factors result in an environment where best practices cannot be disseminated, and meaningful improvements in patient care are not realized to their full potential. The key recommendations noted in this report should be considered for implementation at the level of each province and in each cancer site to optimize patient care.

Surgical cancer care should be integrated into the overall spectrum of provincial cancer services with the capacity for establishing systematic evaluation and the provision of sufficient resources to enact change

- There should be an appointed Lead for Surgical Cancer Care for each province similar to the roles currently established for medical and radiation oncology. As with the Heads of Medical and Radiation Oncology, the Surgical Lead should be responsible for strategic planning, budget allocation, and overseeing both the development of standards of care and quality assurance activities within the province.
- Given the differences in cancer care organization between the provinces, it is expected that this Surgical Cancer Care Lead role will be integrated into each province with the consideration of current surgical care organization. Despite differences in implementation, the overall role and responsibilities should be similar between provinces.

Nationally-implemented standards of care should be developed for each cancer surgery

- It is recommended that a set of national standards of care be developed, similar to those that currently exist in many countries. These distinct standards need to be established based on current research and evidence in surgical cancer services to encourage excellence on both provincial and national levels.
- There should be a gathering of specialty-based communities of practice focused on defining minimal standards for practitioner certification or training, the use of consultative cancer conferences, participation in national quality improvement registries and the establishment of minimal institutional and/or surgeon case volumes.
- These specialty-based communities must consider the integration of specialized nursing, critical care and anaesthesia services, and adequate radiology and pathologic support.
- The evaluation of adherence to these surgical standards of care should be integrated into existing national evaluation structures in order to measure province-level improvements and inter-provincial variance.

Purposeful regionalization of cancer surgical services above and beyond simple consolidation is necessary to improve health care quality and patient outcomes

- Volume itself is not adequate to drive improvements in outcomes. It is imperative that other quality improvement initiatives are incorporated into these centres of excellence based on the requirements outlined in the cancer site-specific standards of care, such as staff training, technology uptake or infrastructure requirements.
- The evidence presented in this report, accompanied by the reported citizens' preference for quality of care despite increased travel time, presents a strong need and support for regionalization of surgeries for high-risk, resource-intensive cancer. Non-regionalized institutions often lack the organizational infrastructure needed to host specialized, multidisciplinary care consistent with modern surgical cancer services.

Regionalization policies should be tailored to meet unique provincial needs

- It is not feasible to establish one single regionalization policy for all provinces and territories due to a need to balance access to care, geographical and health care system governance and oversight practicality factors that are individual to each jurisdiction.
- The volume-outcome effect is one that should be utilized in health care planning, but due to the relative difference in provincial populations, it is truly impractical to delineate a single national threshold for each of the cancer types.

Surgical cancer care should embrace flexible implementation of regionalization policies based on access to care concerns and patient preferences

- The issues relating to access to care as a consequence of regionalizing to selected centres may be ameliorated through the integration of innovative approaches that allow patients to remain at home for part of their cancer journey.
- This approach can take the form of local post-surgical care centres and/or the ability to complete diagnostic assessment pathways, telemedicine and post-surgical consultations and tests at local facilities.

A structured benchmarking process for each specialty should be supported to improve surgical outcomes and inform policy decisions

- In the interest of cancer care quality improvement, all surgical care providers should participate in national disease specific registries to capture core data sets regarding patients, cancers, procedures, adverse events and oncologic outcomes.
- Data collection must be partnered with explicit public data reporting, benchmarking and other quality improvement initiatives, and ideally supplemented and supported by national society derived best practice guidelines.
- Registries have the potential to influence outcomes through a structured benchmarking process, where practitioners are compared to their peers via regular reporting. These reports can act as decision making tools to inform health care planners in addition to encouraging the concept of positive deviance through the sharing of best practices within a discipline.

1.0: INTRODUCTION

CHAPTER HIGHLIGHTS

- Cancer represents a significant burden to individuals, the health system and society. With population growth and aging, cancer incidence has increased and is expected to continue on this trend. Surgery offers the best chance for cure for the high-risk cancers under study
- There is no one cancer surgery delivery approach implemented in Canada, but there is increasing interest in the regionalization of cancer surgery services, an approach that has the potential to improve patient outcomes as the cornerstone of a robust quality improvement initiative
- Esophageal, pancreatic, liver, lung and ovarian cancers require complex surgery to ideally reduce the high morbidity and mortality rates, but outcomes are highly variable on the stage of disease, extent of surgery and location of tumour
- High-risk, complex cancer surgery carries a significant economic burden to patients and the Canadian health care system. While improving patient outcomes is ultimately the most important objective, any initiative that can reduce the burden of disease to the patient while also efficiently using limited health care resources is valuable to all stakeholders

1.1 CONTEXT OF HEALTH CARE DELIVERY AND QUALITY IMPROVEMENT

The absence of health impacts an individual's quality of life on a day to day basis, and also affects the ability of a society to function effectively on a broader level. It is for this reason that governments and organizations devote considerable resources and energy to improving the health status of populations. The World Health Organization (WHO) states that obtaining the highest possible standards of health is a fundamental right of every human being, including access to timely, acceptable, and affordable health care of appropriate quality.[1] Deficiencies in care such as gaps in access or poor delivery of services affect individuals' health and quality of life. The challenge lies in devising a health care system that delivers the best possible care while also balancing the other needs of a society.

Globally, all health care systems are imperfect models of care, with no one system representing the ultimate, ideal system. A good health care system combines cost conscious care with optimal outcomes, but the challenge lies in developing health care delivery strategies that engender the greatest improvement in patient outcomes. Health care organization and planning are continuous processes that must adapt to the needs of the population and the availability of resources to achieve improvements in the quality of health care. In Canada, the number of new cancer cases is expected to increase partly due to population growth and aging, so there is a definite need to re-evaluate the delivery of

cancer care services to ensure continuous quality improvement, particularly with regard to resource-intensive cancer surgery.

As the Canadian health care system considers novel approaches to improving the delivery of cancer surgical care, the Donabedian conceptual framework for quality care improvement helps to describe the relationships between the processes, structure and outcomes involved in health care system improvement.[2] Improvements in outcomes are partly contingent on having quality processes, which would entail the application of best-practice, evidence-based medical care. Examples include the initiation of clinical trials to develop new surgical techniques or test new chemotherapy drugs, the increasing use of minimally-invasive surgical techniques, the establishment and measurement of quality benchmarks, the creation of recommendations requesting the specialization of surgeons and the use of multidisciplinary teams to coordinate the care of patients.[3] Likewise, patient outcomes can also be improved through initiatives that focus on the structure of care, such as adaptable hospital infrastructure and strong regulatory bodies and guidelines. Interventions that target the structure of care require a large amount of coordination between health care system managers, clinicians, hospital administrators, and other key stakeholders, but can also have a high impact on patient outcomes. Structure and/or process improvements are inter-related with improved patient outcomes, and the strongest quality improvement initiatives are those that integrate both factors.

Over the past three decades, there has been increasing interest in the regionalization of cancer surgical care into specialized centres of excellence. This approach to improving the quality of cancer care offers an opportunity to integrate both process-based and structure-based improvement. There is considerable variance in how these regionalization strategies have been implemented across Canada, since these decisions are left to the discretion of each province. Each province has the ability to establish quality improvement programs and approaches to health care delivery for high-risk, resource intensive cancer services. This has led to great variability across the country on surgical outcomes and the delivery of care. Heterogeneous quality of surgical care leads to higher mortality rates, longer length of stay, more post-operative complications, and greater chances of hospital readmission, thus impacting patient health outcomes but also increasing the overall cost of health care.

Throughout this discussion paper, we will present an objective analysis and discussion about the regionalized quality improvement policy approaches that have been undertaken for the provision of high-risk, resource intensive cancer surgical procedures across Canada. We present the potential benefits and limitations of this approach in the Canadian context to assist with evidence based decision making for health care policy planners and decision makers.

1.2 THE BURDEN OF CANCER IN THE CANADIAN HEALTH CARE SYSTEM

While other chronic health conditions play a role in the increasing burden placed on the health care system, the management of cancer care is particularly resource intensive. Cancer poses a significant burden to individuals and incurs a large financial cost to the health care system. According to the 2014 Canadian Cancer Society report, 43% of Canadians are expected to develop cancer, and 25% are expected to die from cancer over a lifetime.[4] It is the leading cause of death in Canada, representing nearly 30% of all deaths in 2011.[4] The burden of disease associated with cancer is expected to increase with the growing aging population, with about 89% cases developing in patients over the age of 50 which will lead to an increase in case complexity and costs.[4]

The increasing burden of cancer care is coinciding with an economic climate where health care expenditures have increased consistently from 7% of the Canadian Gross Domestic Product in 1975 upwards to 10.9% in 2014, with $214.9 billion spent in total.[5] This increase in health care costs has occurred concurrently with rising inflation, an increased burden of chronic diseases and cancer, more costly modern treatment approaches and a growing aging population, a single factor that is greatly associated with higher health care costs due to increased co-morbidities.[5,6]

Cancer screening remains the most cost-effective modality for reducing the burden of disease. Conversely, cancer treatment requires a significant use of health care services,[7] with cancer reported to be the 4th leading cause of hospital admissions in 2008.[8] An estimated $17.4 billion dollars was spent on the direct costs of health care (physician and hospital expenses), and the indirect costs associated with a loss of productivity due to cancer therapies.[9] Unfortunately, screening is presently a small part of the puzzle, since many cancers are detected at a later stage and thus require considerably more extensive surgeries and oncologic services than if a tumour was detected earlier. This is particularly true for lung, esophageal, liver, pancreatic and ovarian cancers. In all these cases, surgery usually offers the greatest potential for cure relative to chemotherapy and radiation therapy.[7] Surgery can be used to remove tumours or cancerous cells, to shrink tumours in preparation for radiation or chemotherapy, or to provide palliative relief from pain.

Whereas the procedures and risks for cataract removal or a knee arthroplasty are relatively homogeneous between patients, cancer surgeries vary in associated risk and resource implications. The five listed cancer sites are considered to be particularly high-risk, resource intensive to treat surgically. These complex procedures carry a higher risk of adverse outcomes, although there is considerable variance in adverse event rates depending on non-modifiable patient related factors (i.e. age, co-morbidities, tumour stage), or potentially modifiable factors such as access to best-practice care, the selection of appropriate resection approaches, surgeon skill level, availability of hospital resources, appropriate use of minimally invasive techniques, access to new technologies, hospital infrastructure and staff training.

Regardless of cancer site, the absolute number of cancer surgeries increased from 137,100 in 2004-05 to 146,000 in 2007-08 despite stable age-standardized rates,[10] representing an evolving burden on health care services in the coming years. Esophageal, pancreatic, liver, lung and ovarian cancer surgeries share this upward trend and will be introduced in the following sections.

1.3.1 ESOPHAGEAL CANCER

The esophagus (or oesophagus) is a multi-layered muscular tube and forms a portion of the digestive system. Cancer can develop at any site along the length of esophagus. The two major types of esophageal cancers are adenocarcinoma and squamous cell carcinoma. In addition, cancerous tumours can spread from other parts of the body (e.g. lungs, liver, or kidneys) to cause metastatic disease.

The lifetime probability of developing esophageal cancer is higher in males (1 in 117) than females (1 in 319) in Canada, with an expected 5-year survival of 14% (13% in males and 5% in females).[4] The expected survival rate for surgically resected early stage cancer is much higher. However, the annual incidence rates are significantly increasing for males, showing an annual 1.4% increase from 2001 to 2010.[4] Surgery remains the major curative option for esophageal cancer when used in combination with chemotherapy and radiation treatments.[11] It involves the surgical removal of part or all of the esophagus. The degree of the resection depends on the location, stage, histology, and grade of esophageal cancer, as well as the patient's health status.

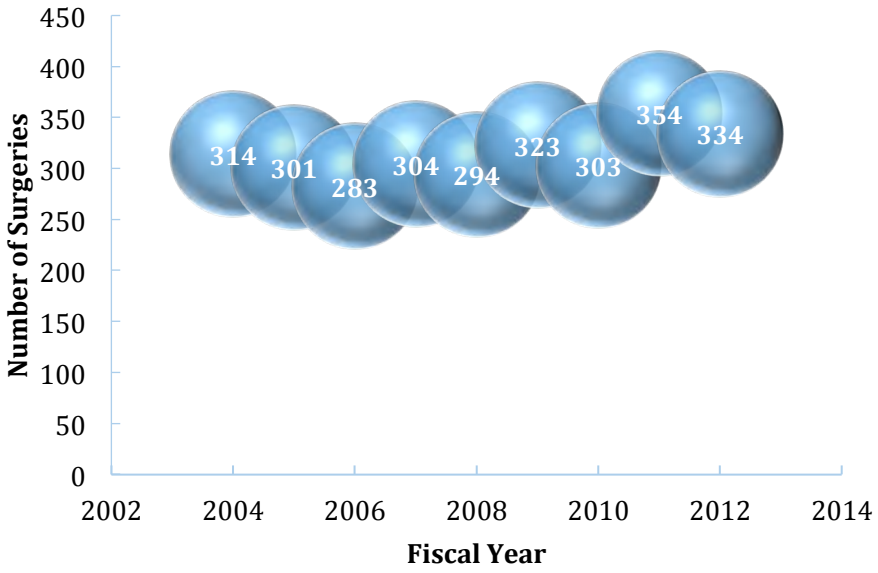
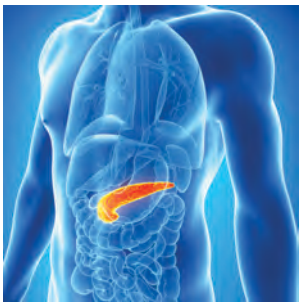


Figure 1.1 Number of Esophageal Cancer Surgeries in Canada (2004-12)

According to hospital admissions data sourced from the Canadian Institute of Health Information, a total of 2810 esophageal cancer resections were performed in Canada (excluding Quebec) between fiscal years 2004 to 2012. The annual number of esophageal resections stayed relatively stable, with a modest 6% increase over the 9-year period (Figure 1.1).

1.3.2 PANCREATIC CANCER



The pancreas is a gland that produces digestive enzymes that are transported to the small intestine through the pancreatic duct. The pancreas also produces insulin and other hormones. Cancer can develop in either the pancreas (typically endocrine tumours) or the pancreatic duct (typically exocrine tumours). Pancreatic cancer is the 4th leading cause of cancer-related death for males and females.[4] The lifetime probability of developing pancreatic cancer is 1.4% (1 in 71 for males; 1 in 69 for females) in Canada (2009).[4] Although no significant changes in incidence and mortality rates are observed for pancreatic cancer over time, the expected 5-year survival rate remains at 7% for both genders.[4]

Surgery could involve the partial or total removal of the pancreas. The type of surgical procedure depends mainly on the stage of cancer, tumour location, and overall patient health. While in-hospital mortality rates are variable depending on resection type,[12] the overall mortality rate after pancreatic cancer resections has been declining over the last 20 years.[12-15] More complex procedures are associated with higher mortality rates, with most post-operative deaths due to surgical complications.[16]

In the period of 2004-2012, a total of 3990 relevant pancreatic cancer resections were performed in Canada (excluding Quebec). The annual number of pancreatic cancer surgeries increased 77%, from 337 procedures in 2004 to 599 in 2012 (Figure 1.2), representing a tremendous increase in the burden of care to the health care system.

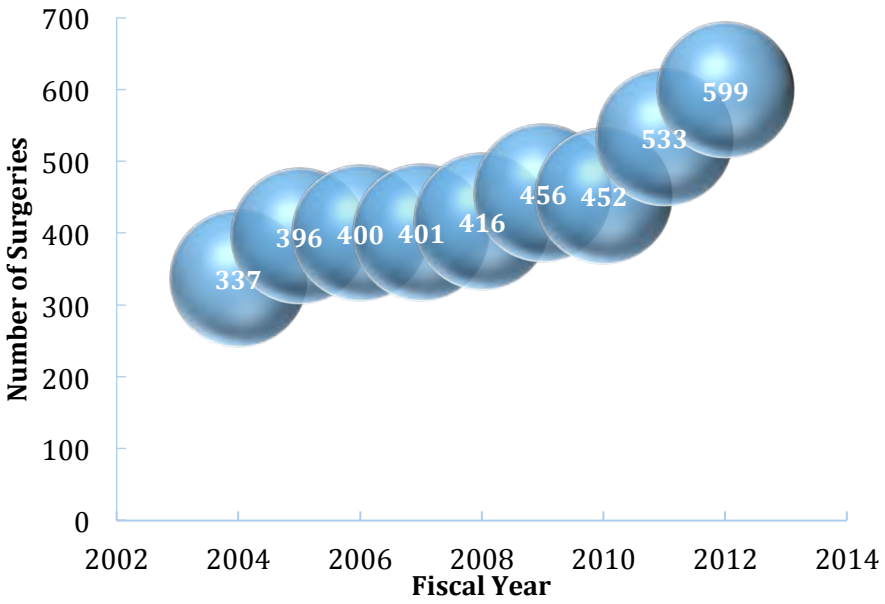
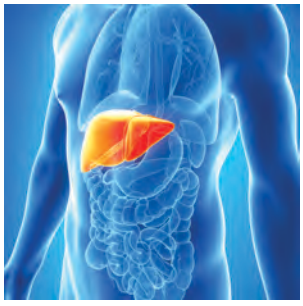


Figure 1.2: Number of Pancreatic Cancer Surgeries in Canada (2004-12)

1.3.3 LIVER CANCER



Liver cancer is one of the cancer types with the fastest increase in incidence rates in Canada.[4,7] The annual incidence and mortality rates have significantly increased for males (2.3% and 3.2%, respectively) and females (2.4%, and 2%), with an expected 5-year survival rate of 18%.[4]

Surgery remains a crucial curative treatment option to control such tumours, except for patients with advanced disease.[17,18] Hepatic resection is a high risk procedure and there has been an increase in the number of such procedures performed over the last 20 years.[19,20] Two-thirds of liver resections are associated with secondary, metastasized colorectal cancers, which significantly increases the degree of surgical complexity. The impact of this complexity on surgical outcomes varies depending on the extent of surgical resection, cancer type and patient co-morbidities.[21]

There has been an increase in the number of liver resections performed over the last 20 years. A pan-Canadian study reported an 80% increase in the rate of liver resections performed from 1995 to 2004, an increase from 3.2 cases per 100,000 adults in 1995 to 5.9 cases per 100,000 adults in 2004.[19] More recent data obtained from the Canadian Institute of Health Information Discharge Abstract Database (DAD) reported that the number of liver resection cases has increased from 693 in 2004 to 1265 in 2012, representing an 82% increase over this 9-year period (Figure 1.3).

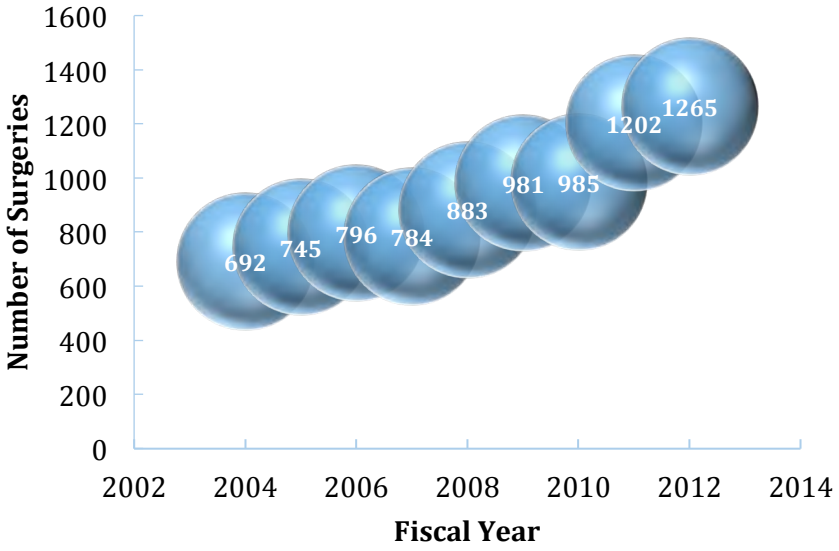


Figure 1.3: Number of Liver Cancer Surgeries in Canada (2004-12)

1.3.4 LUNG CANCER

Lung cancer is the leading cause of cancer-related deaths in Canada, accounting for 27% of deaths in both males and females and an expected 5-year survival rate of 17%.[4] The lifetime probability of developing lung cancer is 1 in 12 for males and 1 in 14 for females.[4] The annual incidence and mortality rates for males have significantly decreased from 2000 to 2009, while no significant changes have been observed over the same time for females.[4] Surgical resection rates for lung cancer have increased over this same period, with in-patient hospital records reporting a 24% increase in lung resections, from 2942 cases in 2004 to 3795 in 2012 (Figure 1.4).

Surgery is the optimal curative option for lung cancer in early stage disease, with the anticipated five-year survival for surgically resected stage I and II disease reported to be near 70%.[22] Lung cancer surgery is performed to remove the diseased lung tissue. There are various procedure options depending on the stage, location, and type of cancer. Some of the common surgical procedures include: Pneumonectomy (removal of a whole lung); Lobectomy (removal of one or more lobes of a lung); and a Segmentectomy or Wedge resection (removal of part of a lobe within a lung). The surgery-related mortality rates depend on the type of surgical technique applied, the extent of resection, and the associated complexities of the procedure.

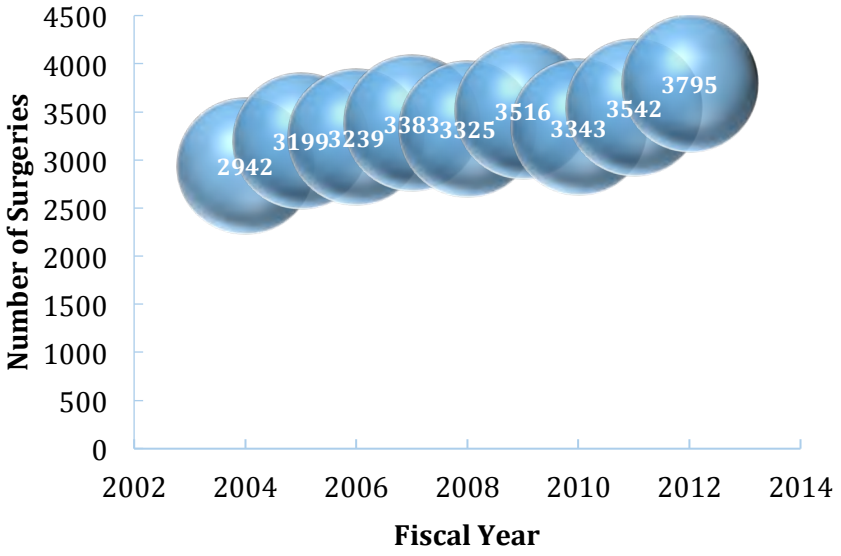
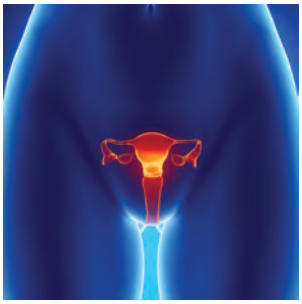


Figure 1.4: Number of Lung Cancer Surgeries in Canada (2004-2012)

1.3.5 OVARIAN CANCER



Ovarian cancer is the most lethal gynecological malignancy.[23] This cancer is relatively uncommon and, given the non-specific nature of symptoms, is often diagnosed at a later stage of cancer.[23,24] Early diagnosis often takes place incidentally during surgery for other indications.[24] The lifetime probability of developing ovarian cancer in Canada is 1.4% (1 in 72), and the expected 5-year survival rate is 42%.[4] Although there has been a significant 1.1% reduction in the annual incidence rate from 2001-2010, the annual mortality rates have significantly increased by 2.2% over the same time period.[4] From 2004 to 2012, a total of 16,949 gynecological procedures for primary ovarian and fallopian tube cancers were performed in Canada, representing a modest 12% increase over the 8 year period (Figure 1.5).

Surgery plays a key role in the management of ovarian cancer, by determining the extent of cancer spread (stage) and influencing decisions on the use of chemotherapy in addition to the removal of the tumour itself (debulking).[25] Due to the close interconnectedness of the female reproductive system, ovarian cancer surgeries are associated with an incredible heterogeneity of risk. For instance, surgery may involve the removal of one ovary (unilateral oophorectomy) or both ovaries (bilateral oophorectomy), the fallopian tubes (salpingectomy), the uterus (hysterectomy), or pelvic and para aortic node dissection along with the removal of as much clinically evident tumour as possible (omentectomy). Depending on the spread of tumour to nearby organ systems, omentectomy may involve

the resection of bowel, diaphragm, or peritoneum. Naturally, the degree of tumour resection will influence the morbidity and mortality rates after surgery.

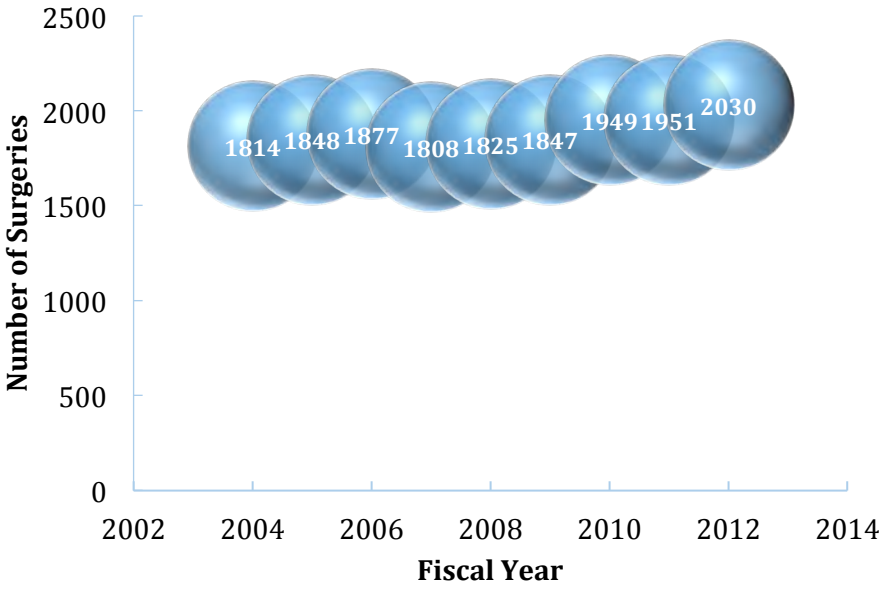


Figure 1.5: Number of Gynecological Resections for Ovarian Cancer Surgeries in Canada (2004-12)

1.4 ECONOMIC BURDEN OF CANCER SURGERIES IN CANADA

The incidence of cancer is rising for the most part in Canada[4]. Surgery is typically regarded as the preferred, and often definitive, treatment option for high risk cancers. The costs associated with cancer surgical procedures are significant and are associated with higher resource consumption due to the high complexity. An Ontario study looking at cancer data from 1997-2007 reported the mean post-diagnosis costs of treatment for high-risk, high resource intensive treatment for patients who survived beyond one year.[26] The highest costs were reported for esophageal cancer ($50,620) from among the 21 cancers studied, which can be attributed to the need for an extended length of hospital stay and a greater need for post-treatment follow-up, resulting in higher physician service costs. The post-diagnosis costs for patients surviving beyond the first year for other high-risk resource intensive cancers were: pancreas ($41,846); liver ($32,717); lung ($29,878); and ovarian cancer ($29,640). The costs included expenditures that are associated with inpatient hospital admissions, physician services, chemotherapy, radiotherapy, outpatient medications, same day surgery, diagnostic tests, long-term care, continuing care and home care.

These are imperfect costing numbers, as they were produced for wait times allocation discussions that included the consideration of supplementary health care services for several of these cancers. Although these costs do not represent the actual costs of surgery in Canada, this is the best available estimate on the cost associated with the treatment of

high-risk, resource intensive surgical procedures. These costs are borne by the health care system, but also in part by the patient themselves, with the time required to travel to appointments, transportation costs and lost opportunity costs in addition to the fees not covered by provincial health plans. Box 1 describes a simplified demonstration of the travel and time costs associated with all hospital visits for the treatment of esophageal cancer.

BOX 1: COSTING CASE STUDY CONSIDERING APPOINTMENTS AND COST OF PATIENT TRAVEL

Patient Stories

John lives in the centre of Niagara Falls, Ontario. He is currently receiving treatment for esophageal cancer at the Juravinski Cancer Centre (JCC) in Hamilton, ON for medical oncology/radiation oncology). He received surgical care at St. Joseph's Healthcare Hamilton. The distance from his home to JCC is 71.3km (45 minutes), and 73.6km (50 min) to SJHH. The parking fee at JCC was $90 for 30 uses and $144.50 at SJHH ($3.50/hour with each appointment taking roughly 3 hours + one 2-week pass costing $50)

For an average patient requiring only Perioperative chemotherapy:

- *Total of 52 visits, not including in-home weekly Community Care Access Centre (CCAC) coordinated home care, 31 trips to JCC, 21 trips to SJHH over 9 months. Total of 52 return trips with parking each day. Total cost of parking is $415. Total cost of car travel, based on an estimate of 40cents/km: To JCC: 4420.6 km or $1768.24 total. To SJHH: 3091.20km or $1236.48 total.* ***Total cost is $3420 for parking and travel to appointments and nearly 100 hours in travel time (98hrs)***

For an average patient requiring Pre-operative chemotherapy/radiation therapy:

- *Total of 66 visits, not including 6 months of weekly in-home CCAC visits, 45 to JCC and 21 to SJHH). Total of 66 return trips with parking each day. Cost of parking at JCC is $450 ($90*5 for 50 visits, cheapest) and SJHH is $144.50 for a total parking cost of $595. Total cost of car travel, based on an estimate of 40cents/km: To JCC: 6417km or $2566.80. To SJHH: 3091.20km or $1236.48 total.* ***Total cost is $4398.28 for parking and travel to appointments and 102.5 hours in travel time***

High-risk, complex cancer surgery carries a significant economic burden to the Canadian health care system. While improving patient outcomes is ultimately the most important objective, any initiative that can reduce the burden of disease to the patient while also efficiently using limited health care resources is valuable to all stakeholders.

In the next section, we will discuss the definition of regionalization of care, and present associated challenges and limitations of this approach.

2.0: DEFINING AND EVALUATING REGIONALIZATION

CHAPTER HIGHLIGHTS

- The definition of regionalization varies based on particular discipline of study. Furthermore, our best efforts could not find a consensus definition of regionalization of cancer surgical care in the literature
- Regionalization is more than a mere shift of patients from multiple small centres into one central facility, but is instead a planned process specifically targeted at improving quality and outcomes of care. Based on expert opinion, we define regionalization as: ***"the deliberate reorientation of cancer surgical procedures, based on explicit and planned processes and structures, with the intent of improving the quality of care"***
- A lack of consensus definition limits the ability to evaluate outcomes of 'regionalization' across various jurisdictions. If this is a strategy to improve quality of care, we need to know exact steps taken to implement it elsewhere. More often than not, volume is used as a surrogate measure to evaluate the impacts of 'regionalization'
- Volume alone is not a quality improvement measure, but it is an important component of a multifaceted organizational quality improvement approach that emphasizes specialized staff training, application of new knowledge, and benchmarking outcomes over time among other initiatives.

2.1 DEFINING REGIONALIZATION

Regionalization is a broad, loosely defined, and context-specific term that has been used in the disciplines of geography, globalization, sports, politics, health care policy and administration, business, and emergency planning, to mention a few. The definitions vary based on the specific discipline and intent of regionalization. For example, in emergency planning it is defined as, "the matching of medical resources to patient needs to maximize health benefits and outcomes while minimizing cost and use of resources over a specified geographic area".[27] On a broader health care system level, it is often used to define the transference of responsibilities for health care planning, organization, and delivery of health care services to local regions.[28] The recent development of Local Health Integration Networks and Regional Health Authorities are examples of forms of regionalization. The main goals of regionalization of health care services to local regions include cost

containment, improving accountability and responsiveness for local health needs, and increasing public participation in health care decision-making.[28]

A review of literature reporting the impacts of cancer surgery allocation to high volume centres showed that a consensus has yet to be reached for a consistent definition of regionalization. This term is often used interchangeably with 'centralization', 'consolidation' or 'designation' of cancer care. According to Raval, Bilimoria, & Talamonti (2010), "Regionalization is a term used to describe shifting a set of procedures to certain hospitals (e.g. high-volume) to improve surgical outcomes".[29] This means that typically lower volume centres (often located in rural areas) are closed, directing the patients towards higher volume centres (typically in urban areas). Regionalization of surgical procedures can also contain cost, increase accountability and responsiveness to local needs, but it can also be directed at enhancing quality of care initiatives to improve outcomes of surgery.

The lack of an available definition for regionalization in the literature leads to an inability to compare outcomes of regionalization across published studies. As with clinical data collection, it is impossible to consider differences between approaches when there is no standardized terminology. Processes that do not necessarily constitute regionalization are often classified as such, and these confound the study of regionalization outcomes. 'Passive Centralization' is such an example. Passive centralization is the 'unintentional' consolidation of surgical procedures to specific sites based on natural geography (e.g. a central service site for scattered rural remote areas), for cost containment, or availability of surgeons and staff in urban centres. This is in contrast to 'Active Centralization', which is a process that is actively undertaken with the intent to improve outcomes of surgery while ensuring safe, effective, and efficient patient care. Regionalization of high risk, high resource intensive cancer surgical procedures in Ontario is an example of 'active centralization'. Given the challenges described above, a more suitable definition of regionalization was required in order to classify cancer treatment services as 'regionalized' to facilitate making comparisons across the provinces in Canada. Based on the field knowledge of our team members, review of the literature, and discussion with experts, we defined regionalization as:

"the deliberate reorientation of cancer surgical procedures, based on explicit and planned processes and structures, with the intent of improving the quality of care"

Therefore, a mere increase in facility volume (centralization) does not necessarily equate to regionalization. Centralization is not regionalization. This definition closely matches with policies adopted by Cancer Care Ontario to regionalize high risk cancer surgical procedures.

2.2 HOW IS REGIONALIZATION EVALUATED?

How we choose to evaluate the outcomes of regionalization of cancer surgery has implications on effective resource utilization and on patient quality of care. Evaluation usually takes place using either existing literature or retrospectively reviewed administrative databases. Both these approaches have certain trade-offs based on the quality of the data and how it applies to each particular population. As noted above, existing literature may not be compatible due to varying definitions of regionalization. With no clear definition of the system under discussion, it may be more akin to comparing apples with oranges. Furthermore, the precision of the data may be unknown due to inconsistencies in data collection or other biases. Administrative datasets carry their own threats to validity and depend very much on the standardization of data definitions and collection procedures between centres.

Regardless of how well the data is collected, the impact of changes in a complex, multi-dimensional system is difficult to predict. The statistical and economic models require extensive data to confidently predict the impact of changing certain factors on outcomes of interest. High quality data for such models on a national level, for all possible variables that may impact the performance of a system, is not always available and indeed, a large scale evaluation of regionalization has yet to be completed before this report. Therefore, considering all the optimization efforts presently being applied within a complex system, we are able to predict many but not all eventual repercussions of these manipulations. Sometimes the impact of changes to the delivery of services implemented at a system level is only evident later in time.

The effects of early adoption of regionalization has been evaluated in the literature in an attempt to demonstrate the benefits of regionalization approaches. In addition to evaluating the outcomes of regionalization in monetary terms, evaluations can also focus on the improvement of patient outcomes, the successful implementation of high quality surgical procedures or adherence to evidence-based guidelines and standards, among others. The majority of studies use administrative data to compare outcomes of high vs. low volume surgical centres.

Volume as a Surrogate Measure

Institutional and surgeon volume have been used to evaluate the impacts of regionalization on outcomes. While the literature tends to demonstrate a positive association between a higher volume of cases and better patient outcomes, there are other quality of care factors

in high volume or tertiary care centres that also affect outcomes. Our literature review alludes to the fact that volume alone does not predict the reduction in mortality rates and improvements in overall survival that have been seen over time. Other potential factors include provider specialty, the use of multidisciplinary teams, specialized hospital infrastructure, improved surgical instrumentation, nursing staff experience and/or specialization, rescue of ill patients and better surgical techniques.

One of the potential concerns regarding the use of volume as a predictor of outcomes is that it may unfairly discriminate against low-volume providers with favourable outcomes.[170] In the interest of improving the quality of care, it may seem reasonable to apply benchmarking techniques to highlight centres that are more successful at selected outcomes. There are concerns regarding the low statistical power associated with small sample size in individual low volume providers that may hinder a reliable comparison with either their high volume counterparts or against a national benchmark, but this approach may prove to be useful.

Even with these considerations, the benefits of using volume outweigh its limitations. Volume is an easily measurable and frequently reported variable, and is clearly associated with improved surgical outcomes.[29,30] It is easily acquired from administrative data for hospitals and for surgeons. Although the debate remains unsettled on a direct causal relationship between volume and outcomes, better outcomes are still achieved for patients if surgeries are performed at high volume sites.[10] Therefore, volume remains the best available indictor to evaluate surgical quality in the absence of other viable alternatives.[29] While understanding its limits, volume will be used as a surrogate measure for evaluating outcomes of cancer surgical procedures in this report.

2.3 CHALLENGES ASSOCIATED WITH REGIONALIZATION

While regionalization of cancer surgical care has a potential for quality improvement that may serve the interests of patients, providers, and the payers, it is not without criticism. Any shifts in the structure of care directly or indirectly impacts the users, providers, and funders of healthcare services. Table 2.3.1 summaries some of the speculated risks and benefits of regionalization policies.

TABLE 2.3.1: BENEFITS AND UNINTENDED CONSEQUENCES OF REGIONALIZATION

PROS	CONS
Improved patient-based outcomes • Lower mortality rates; shorter length of stay	Out-of-pocket patient cost and burden of travel[32] (also depicted in Box 1)
Allows for dissemination of guidelines and standards	Loss of local pre-and post-cancer surgical services
Enables capturing of reliable data for evaluating quality of surgical care	Loss of surgical expertise at local hospitals[31]
Provides opportunities for partnering with multidisciplinary staff	Longer surgical wait times in high volume centres
Encourages collaboration for research and innovation to improve processes of care	Potential lack of access to informal care/lack of support for families and caregivers
Potential 24/7 access to specialty care at designated centres	Providers' resistance among providers towards shift in established care processes
Promotes benchmarking and other surgical quality improvement measures	Significant challenges to implementing regionalization if hospital's revenue is directly tied to the number of treated patients[119]

In short, the regionalization of surgical care often presents patients and caregivers with a dilemma, requiring them to choose between quality care and accessible care. The concerns of providers revolve around resistance towards any shifts away from existing practices, financial implications, and disagreements regarding the use of volume as a quality metric. The system-level concerns focus on the practical challenges faced by policy makers and healthcare planners to devise comprehensive strategies and guidelines that adequately address stakeholder concerns, geographic specificities, and healthcare demands.

The successful implementation of regionalization policies and standards may require provincial cancer agencies to provide strategic direction and leadership for surgical care. The Ontario experience of the regionalization of thoracic surgeries provides an example of strategies that have been adopted to assist with the implementation of regionalization policies. Although an evaluation of risk-adjusted outcomes has yet to be conducted, the success of this policy has been reported by the resultant increase in surgical volume at designated centres.[119] In Ontario, other strategies that have been utilized to promote the implementation of regionalization include: 1) Extensive discussions between concerned healthcare planners (cancer agency senior leadership), administrators (Chief Executives of hospitals), and thoracic surgeons; and 2) Use of additional funds to encourage compliance of hospitals with surgical standards and to lower wait times by increasing number of procedures.[119]

Regionalization policies that adequately address the stakeholders' concerns can improve the success of quality improvement initiatives by ensuring coordination, collaboration, and client-satisfaction.

3.0: LITERATURE REVIEW: EXISTING EVIDENCE ON REGIONALIZATION

CHAPTER HIGHLIGHTS

- Overall, compelling evidence from numerous studies contrasting provider (hospital, surgeon) volume, or provider specialty and improved outcomes (in-hospital mortality, morbidity, length of stay, or overall survival) has been published in last two decades.
- The bulk of the literature and pan-Canadian evidence would support the regionalization of lung, esophageal, liver, pancreatic and ovarian cancers on hard objective measures such as mortality and length of stay.
- The relative significance of facility volume, surgeon volume, surgeon specialty, or institution specialization on such outcomes is still undetermined.
    - The extent of conflicting literature can be confusing for patients and families seeking information to aid decision-making about where and with whom to seek cancer surgical care. This can impact their willingness to travel farther distances for care.
- Fundamentally, it is not reasonable or practical to identify a single number threshold that defines a high volume centre.
- There is a lack of studies that consider more difficult to measure outcomes such as adherence to best practice standards, complication rates, survival and long term results, largely because these outcomes are not reliably captured in administrative datasets, if at all, and there has only been recent interest in the evaluation of such endpoints within the academic community
    - Survival and complications affect all patients undergoing the surgery and thus would offer a significantly better power to evaluate the centralization of surgical cancer services.

3.1 LITERATURE REVIEW AND METHODOLOGY

In this section, a brief summary of existing literature on the modifiable, provider-related (facility, surgeon) factors that can impact outcomes of care is presented. Any evidence on the impact of regionalization at the patient or system-level will be discussed in this section.

In total, 110 relevant studies were abstracted from the literature (see Appendix 1 for detailed search criteria and summary tables). The studies varied based on population size, country of origin, and reported outcomes. Although a formal methodological quality assessment was not conducted, only population-based studies were included in order to avoid biases in single institution studies, such as those related to socioeconomic status,

race, or co-morbidities. The selection of population-based studies allows for a theoretically greater generalizability of conclusions to an overall population leading to the identification of factors that can lead to population-wide improvements in care. Dimick et al. supported the claim that data from single-centre studies is not a good representation of national trends in rates of procedures performed over time.[20] The findings of such studies may not be generalizable to a broader range of institutional settings given the differences in standards and procedures used to provide care. Figure 3.1 demonstrates the flow of the completed literature search and review process.

3.2 VOLUME-OUTCOME ASSOCIATION

The positive impact of facility/surgeon volume on post-operative outcomes for various cancer types has been demonstrated extensively in the literature. The results of these studies have prompted various researchers and policy makers to urge for the regionalization of complex surgical procedures.[21,34-39] It is important to note that there was a disparity in the number of studies reporting on volume-outcome association depending on the cancer type, with liver and ovarian cancer represented by fewer analyses than the other cancers. In-hospital mortality was the most reported outcome while reporting of other outcomes such as length of stay, morbidity, and overall survival was inconsistent or incomplete. Only significant associations after adjusting for patient case-mix are reported over the course of this review document. It is also important to note that the type of procedure being evaluated in a study was identified and reported. The procedures differ in complexity and associated mortality and morbidity rates, hence, the reports that fail to account for the types of resection could potentially bias the results.

In spite of inherent differences in surgical approaches and the complexity of procedures, numerous studies reported improved clinical outcomes, even if not statistically significant, at high volume centres for esophagus, lung and pancreatic cancers (see Appendix 1). These associations held true after adjusting for patient case-mix for the majority of studies (Table 3.1). The strongest evidence for a reduction in mortality rates with increasing volume was reported for esophageal cancer surgery. A large body of evidence, including systematic reviews and meta-analyses, support referral to regional, specialized, high-volume hospitals for esophageal surgical procedures.[18,40] The operative mortality reported in these studies varied widely possibly due to the heterogeneity of the study populations or differences in study periods.[18,19] Relatively fewer studies reported on length of stay and overall survival, however, the length of period over which these survival rates were calculated was not clearly stated.[41-47]

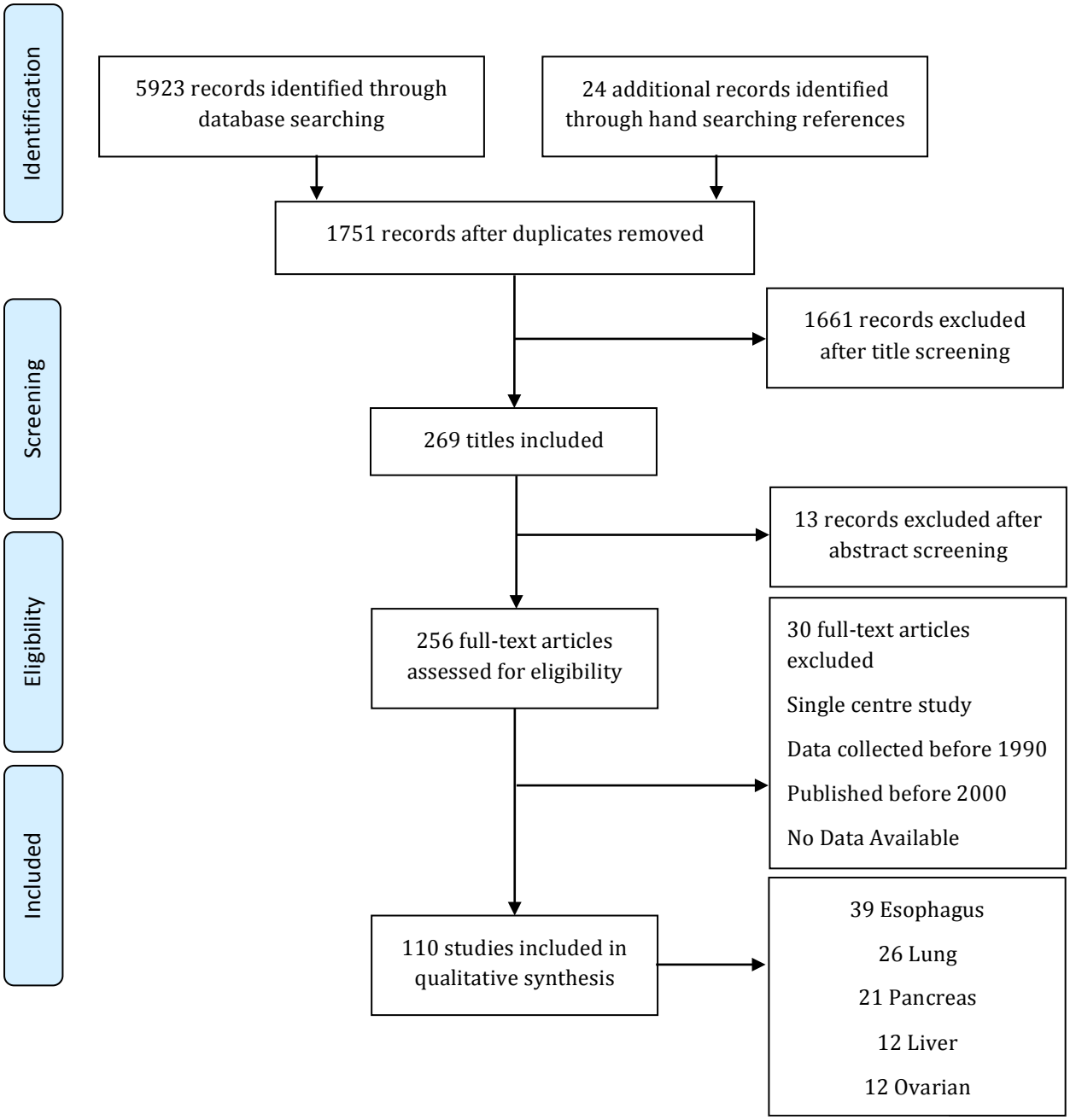


Figure 3.1: Flow diagram depicting literature screening process

The volume–outcome relationship for hepatic cancer surgical procedures has rarely been explored.[48] The most commonly reported outcomes include mortality and length of stay.[18-21,37,38] While an overall downward trend in mortality and morbidity rates post-hepatobiliary surgical procedures was observed in general, a significantly larger decrease in mortality and length of stay at high volume centres was reported.[20,38,49-54] In a pan-Canadian study, the increase in number of procedures being performed in high volume centres was associated with a reduction in the rates of perioperative mortality (from 5.8%

in 1995–1996 to 4.2% in 2003–2004).[19] The mean length of stay decreased from 12.1 to 13.2 days over the course of 1995 to 2004.[19]

The most inconsistent and conflicting evidence in favour of centralizing surgical cancer services was found for ovarian cancer surgery. The absolute reduction in mortality for ovarian cancer after regionalization was less than that shown for lung, esophagus, and pancreatic cancer procedures.[55] In-hospital mortality was seldom discussed as an outcome in these studies. This may reflect the proportionally lower mortality in these cases and as such, discrepancies are more difficult to detect. While treatment in tertiary, high volume centres was shown to be an independent prognostic factor predicting better prognosis and survival of ovarian cancer, staging of disease and complete cytoreduction also predicted outcomes of surgery.[23,56,57] In ovarian cancer surgery, hospital volume was reported to be associated with other metrics of quality care including lower re-operation rate, provision of guideline-based care, better staging for early-stage disease, more extended cytoreduction for advanced-stage cancers, performance of lymphadenectomy, receipt of post-operative chemotherapy, fewer prolonged hospitalizations, and lower ostomy (complication) rates.[55,58,59] The adherence to guidelines is particularly pertinent as it is associated with better outcomes and the literature reports that low volume hospitals and surgeons are less likely to adhere to the guidelines.[60]

Across all cancer types studied, post-operative complications are a major cause of in-hospital mortality.[16] An improvement in rates of complications at high volume centres were reported in a few studies.[12,13,16,58,59,61-64] Regrettably, there were no single standard criteria for classification of post-operative complications for any of the cancer types, so it was difficult to assess reported complication severity. Wright et al. found that the high volume centres for ovarian cancer had higher adjusted complication rate, yet, showed better survival.[59] Further analysis concluded that patients experiencing a complication at low-volume hospitals were nearly 50% more likely to die as compared to those in high volume centres. Ghaferi et al. also found similar complication rates for gastrectomy, pancreatectomy, and esophagectomy at different hospital volumes, however, a higher failure to rescue patients from adverse events was associated with low volume hospitals.[66] Therefore, the ability of an institution to manage complications, even if they do not reduce the overall rate of complications themselves, seems to predict mortality.

Contrarians of volume-outcome associations argue that it is incorrect to attribute positive outcomes to high-volumes alone, a position that is supported by some literature. The volume-outcome relationship could be a result of various complex interactions between factors that may also lead to improved outcomes. For example, the benefits of restricting complex high risk procedures to high-volume centres could be a result of superior surgical outcomes at a particular site leading to more referrals, which could increase procedural volume at that site.[11] The improvement in outcomes could also be attributed to better

patient selection, advanced operative techniques, better perioperative and post-operative management of cases, and specialized surgeon training.[50,68]

Surgeon Volume and Outcomes

The association between surgeon volume and mortality, morbidity, or length of stay was less frequently reported in the literature. Only twelve studies included in this review reported the impacts of high surgeon volume on patient specific outcomes.[16,23,25,48,55,58,69-73] Although reduction in mortality rate for pancreatic,[16,72,73] esophageal,[41,69,74,75] lung,[69-71]and ovarian[55] cancer was reported with increased surgeon volume, arguments remain unsettled for the benefits of consolidating surgeries to high volume surgeons vs. high volume centres. While studying the impacts of volume on short term morbidity, 30-day mortality, and long term prognosis, Sundelof et al. reported a high level of association between surgeon and hospital volume, hence the reported outcomes were similar for both the variables.[76] Uncertain results were found in studies that tried to find the relative significance of one variable or the other. For instance, Derogar et al. compared the relative significance of hospital and surgeon volumes on short term and long term risk of mortality.[45] After adjusting for the effect of hospital volume and surgeon clustering effect, short term mortality risk was not significantly associated with surgeon volume. The authors asserted the conclusion that factors related to hospitals (i.e. intensive care units) but not volume, impacted short term mortality risk. However, the risk of long-term mortality was significantly associated with surgeon volume, even after adjusting for hospital volume and surgeon clustering effect.[45]

3.3 PROVIDER SPECIALTY AND OUTCOMES

Surgeon speciality was not studied in the majority of the literature associated with pancreatic, hepatobiliary, lung, or esophageal cancers, with the exception of ovarian cancer. In lung cancer regionalization literature, the few studies that investigated provider speciality reported non-significant differences between rates of mortality, length of stay, and overall survival when comparing patients outcomes of surgeries performed by thoracic vs. general surgeons.[78-80] The outcomes were consistent across pneumonectomy, lobectomy, and general lung resections. However, the number of lung cancer-specific studies is too small for any conclusive conclusions to be made.

In gynecological surgery, the extensive literature has reported that initial surgical care by a gynecological oncologist has been found to be associated with a higher likelihood of comprehensive surgical staging, optimal primary cytoreductive surgery, adherence to recommended guidelines, and superior long-term outcomes.[81-86] The advantages associated with specialized surgeons also appears to extend to advantages to using specialized hospitals to perform ovarian cancer surgery. Vernooij et al. reported that specialized hospitals are shown to have significantly lower mortality and better overall

survival compared to general hospitals.[23] In addition, the level of specialization of the hospital was positively associated with adequately staged, optimally debulked patients.[23]

The interplay between surgeon-specific factors and hospital-related factors and outcomes was demonstrated in some studies as well. For example, low volume surgeons at high volume centres were reported to have comparable outcomes for hepatic procedures as those of high volume surgeons at the same centre.[31,87] Similarly, gynecological oncologists working in cancer centres were reported to be twice as likely to attain optimal cytoreduction, when compared to general gynaecologists.[88]

TABLE 3.1. SUMMARY OF STUDIES REPORTING POSITIVE OUTCOMES FOR HOSPITAL AND SURGEON VOLUME

		Positive Outcomes for Hospital Volume	Positive Outcomes for Surgeon Volume
Esophagus	Mortality	[34,36,46,62,113,134-139,141,145,151]	[41,45,69,74,75]
	Complications	[62,138]	[63]
	Length of Stay	[138,139,145]	--
	Survival	[76,118,141,148]	[45,76]
Pancreas	Mortality	[12,13*,15,16,64*,94,101,103,104,106, 107]	[16,56,72,73]
	Complications	[13*,15,16*]	[16*]
	Length of Stay	[16*,64*,101,103,104,106]	[16*]
	Survival	[13*,16,105]	---
Liver	Mortality	[18,19*,20,21, 37,38]	---
	Complications	---	---
	Length of Stay	[19*,37,38]	---
	Survival	[48*]	[48]
Lung	Mortality	[34,70,88,112,116,119,121,122,125,128*]	[69,70,71]
	Complications	---	---
	Length of Stay	[88,121]	---
	Survival	[118,122]	---
Ovarian	Mortality	[55*,25*,58*,59,158,57,160*]	[55,24*]
	Complications	---	---
	Length of Stay	[55,58,59]	[25*,55*,58]
	Survival	[25*,57,58,158,160*]	[23,58*]

**Association insignificant after adjustment for case-mix*

3.4 EVIDENCE FOR REGIONALIZATION

Early adoption of cancer surgery regionalization has led to the initiation of studies reporting on outcomes of regionalization as a cornerstone of quality improvement programs. The impacts of regionalization on surgical procedures have been studied across various settings and in different jurisdictions.

The literature appears to report a positive association between regionalization and morbidity and/or mortality across all five cancer types, even if it is a weak association. Across many jurisdictions, the literature consistently reports improvements in survival (2-5 year), and both post-operative and 30-day mortality and morbidity rates following the implementation of regionalization policies for esophagectomy.[11,40,89-91] This observation appears to hold true with pancreatic surgery, which has seen a gradual increase in the number of resections performed in high volume centres.[12,13] One study in the Netherlands showed a significant reduction in rates of mortality (24% to 2.6%), and morbidity (82% to 38%) after pancreatic cancer surgery while comparing pre-and-post regionalization outcomes.[13] Similarly, the proportion of ovarian cancer patients undergoing ovarian resections in high volume centres, and the proportion of procedures being done by high volume surgeons is reported to have increased over the last 14 years.[55] Regardless of cancer site, significant reductions in mortality rates were reported in studies comparing results of providing care in designated centres pre- and post-centralization.[56,92] A significant regionalization of hepatic cancer surgical procedures over the last decade to high-volume centres has also been reported in the US and Canada, with reported significant improvements in mortality rates.[19,39] This consistent reporting of outcomes improvement across all studied disease sites leads one to believe that the regionalization of surgical cancer services offers positive benefits to patients.

3.5 OPTIMUM VOLUME THRESHOLD

One of the main objectives of this systematic review was to provide an evidence-based volume threshold for each cancer type at which optimum outcomes could be achieved. Early results of the regionalization of pancreatic, esophageal, and liver cancer procedures using different volume thresholds and standards has been reported in the literature.

The extent of the literature studying volume-outcome associations for esophagectomy allowed pooling of data and controlling for potential confounding variables (e.g. age, sex, co-morbidities) for meta-analyses. While positive results have been reported from the meta-analysis of data, it has been reported that it is necessary to perform at least 20 esophagectomies per year to reduce mortality to less than 5%.[91] This observation appears to be supported by other literature reporting higher and widely varying mortality rates for less than 20 esophagectomy cases per year.[93] For pancreatic cancer, a volume threshold of 10 pancreatic procedures per year was proposed.[94] Lung cancer presents a curious case in that although the annual case volume for lung cancer is larger than that of pancreatic or esophageal cancer, there is relatively limited evidence to support volume standards in lung cancer surgery[95] and there were no common criteria across studies to indicate potential volume cut-offs. Lastly, according to the ovarian cancer guidelines disseminated by the National Comprehensive Cancer Network (NCCN), the hospitals are classified as high-volume if they perform $\geq$20 cases of ovarian cancer per year, and the surgeons are

classified as high-volume if they perform ≥10 cases of ovarian cancer per year.[60] The volume cut-off for liver cancer surgeries was not reported in the included literature. Relatively small number of studies limits our ability to provide such comparisons as well.

The review of literature demonstrated disagreements in the use of volume thresholds to classify institutions or surgeons as high or low volume. Studies comparing the annual volume of procedures often had overlapping volume thresholds defining high vs. low volume categories.[96] This further complicates the process of comparing studies to identify volume thresholds in order to achieve best possible patient outcomes. In addition, it has been suggested that the open-ended volume thresholds in the highest volume categories may underestimate the actual mean number of surgeries performed per year.[97] Therefore, the outcomes demonstrated in high volume categories may be a result of actual (higher) mean volume rather than the threshold used for the high-volume category. This threshold is expected to vary for each of the cancer types given the varying levels of complexities associated with each of the surgical procedures.

Fundamentally, it is not reasonable to identify a single number threshold that defines a high volume centre. Practically speaking, the volume-outcome effect is demonstrated even with institutions with the highest case volume, although it eventually does not make a clinically significant difference and would be impractical to implement a defined value. As such, the volume-outcome effect is one that should be utilized in health care planning, but not with such granularity as to demand a threshold.

3.6 LIMITATIONS

The association between volume consolidation and positive outcomes is not without criticism. In general, the literature is lacking consensus on the relative importance of facility vs. surgeon volume at affecting the outcomes of surgery. The heterogeneity in patient co-morbidities, surgeon specialty, facility size, and volume thresholds limits the ability to draw valid comparisons between different studies while varying study designs, non-consensus-based volume thresholds, conflicting findings, small sample sizes, low quality of data sources, heterogeneity of comparison groups, and definitions of outcome measures limits the ability to provide conclusive results.[29] The small number of available studies and heterogeneity of data limits the ability to conduct a meta-analysis for most cancer surgeries.[95] Finally, long term survival assessment is a highly patient-important metric, but it is also dependent on tumour stage, which is not always included in the analysis.[89]

Even though the majority of studies reported improved outcomes in high volume centres or for high volume surgeons relative to low volume hospitals and surgeons, the difference was not always statistically and/or clinically significant. This limits the ability to draw statistically sound conclusions on whether the high volume centres and surgeons actually

show improved outcomes. In addition, the quality of data used to study volume-outcome association has inherent limitations. Most of the studies, if not all, used administrative data to study the volume-outcome association. Such data is collected for administrative and billing purposes and thus direct cause-and-effect relationships cannot be determined with confidence from the analysis of such data given the possible differences in data coding practices.

Lastly, the review found that comprehensive reporting of cancer surgery systems in place for the delivery of high-risk, resource intensive surgical procedures in each Canadian province or territory is largely non-existent. While steps to improve quality of surgical care have been initiated in other provinces, Ontario is the only province with formal steps and published guidelines for regionalization of certain high-risk procedures (pancreatic, hepatic, esophagus, lung, gynecological cancers),[17,60,98] although a few other provinces have taken steps to actively regionalize some cancer site procedures. In addition, there is little research into whether these efforts have helped or hindered the quality of cancer care from a system-level perspective. Further research is required to compare system-level outcomes such as administration costs prior to regionalization activities with the post-regionalization period in order to adjudicate the overall benefit.

3.7 CONCLUSION

The success to which consolidation of care to high volume centres or surgeons improves patient outcomes has yet to be fully studied, although it appears that the potential to greatly impact patient survival, length of stay and morbidity is possible, if implemented in ideal situations. The conflicting evidence of the relative significance of provider (surgeon, hospital) volume, surgeon specialty or hospital designation alludes to the fact that improvements in outcomes are more likely to be caused by the cumulative effect of practitioner training and multidisciplinary collaboration, an adequate number of practitioners in one centre, balanced case volume and complexity, readily available consultation services, specialized nursing and anesthesia services, and adequate radiology and pathologic support.

Volume is not a stand-alone factor explaining all improvements in outcomes. The presence of multidisciplinary teams, well-trained staff, and the resources available to efficiently recognize and treat post-operative complications are all factors associated with high volume centres that cumulatively improve outcomes of care. The best possible surgical outcome may be achieved through the utilization of expert surgeons in high volume centres equipped with cutting edge technology, perioperative institutional standards and supported by specialized multidisciplinary teams. The experience of surgical team, their ability to rescue complicated cases, and availability of multiple surgeons for cooperation and planning of complex cases may result in better outcomes of care.

A majority of the literature points towards improved, even if not statistically significant, outcomes associated with high volume hospitals. Evidence regarding the impact of high surgeon volume is comparatively less clear. Skepticism remains in the use of findings from the literature to provide an evidence-based discussion on the impact of regionalization on surgical outcomes. The limited strength of evidence and heterogeneity of results should be accounted for in identifying volume thresholds.

Fundamentally, the volume of cases completed at a given centre is not an all-encompassing metric. It is not just the simple sum of all the components in care, as those components are inextricably linked and overlapping. This is what makes dissecting down further impossible and explains the heterogeneity of results. It is, however, the most robust statistic available to decision makers and as such, is useful in measuring and evaluating institutions. It is potentially best utilized as a starting point for the development of a cancer surgery quality improvement strategy and must be a key contributor to that conversation.

4.0: ANALYSIS OF PAN-CANADIAN DATA

CHAPTER HIGHLIGHTS

- Hospital volume was a significant predictor of mortality for four of the five cancer surgeries, even in the presence of surgeon volume and specialty. Surgeon volume significantly predicted both outcomes only for liver cancer, while controlling for the influence of hospital related factors. However, it is necessary to note that these three variables are not mutually exclusive. A list of factors significantly associated with in-hospital mortality and length of stay in adjusted analysis is presented in Table 4.0a.
- Ontario, being the most populous province, showed the biggest reduction in number of hospitals performing these surgeries for lung, liver, pancreatic and esophagus cancers. Differences exist in provinces in crude in-hospital mortality rates and length of stay. The trends vary based on specific cancer surgery of interest, with no one province demonstrating the best outcomes across all cancer types
- Travel times slightly increased between the beginning and the end of the study period almost irrespective of patient location. As surgical centres closed, whether as a result of passive or active regionalization activities, the catchment areas of the remaining centres widened, revealing a longer travel time for all but the most urban centres. Across all cancer sites, the proportion of patients who had to travel more than one hour to access care increased as the number of centres that provide surgical cancer services decreased. This data confirms that the regionalization of some services to high volume, central locations occurs at the expense of patient travel time.
- There were differences between the provinces in age-adjusted resection rates per capita. However, a clear association between in-hospital mortality rates and associated resection rates could not reliably be established.

Limitations:

- As can be expected based on the population distribution of Canada, there is a large variation in the number of surgical cases completed per province, even temporally during the study period. This limits the ability to perform year-to-year comparisons on mortality rates, so a 9-year (2004-2012) average mortality rate is reported throughout this section to facilitate comparisons and discussion.
- The small annual surgical volume in less populous provinces limited our ability to reliably determine inter-provincial differences in outcomes of interest in regression and survival analysis.

- It should be noted that the surgeon specialty could not be independently verified, which limits our ability to draw accurate comparisons between specialist and general surgeons in the outcomes of interest.
- The inter-provincial differences could not reliably be determined given the small surgical case volume in certain jurisdictions.

TABLE 4.0A: SIGNIFICANT ASSOCIATIONS BETWEEN SELECTED COVARIATES AND MORTALITY

Covariates	Esophagus		Pancreas		Liver		Lung		Ovary	
	IHM	LOS	IHM	LOS	IHM	LOS	IHM	LOS	IHM	LOS
Hospital Volume	✔	✔	✔	✔	✘	✘	✔	✔	✔	✔
Surgeon Volume	✘	✔	✘	✔	✔	✔	✘	✔	✘	✔
Surgeon Specialty	✘	✘	--	--	--	--	✘	✘	✔	✔
Age	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Co-morbidity Score	✔	✔	✔	✔	✔	✔	✔	✔	✔	✔
Sex	✘	✔	✘	✘	✔	✘	✔	✔	--	--
Resection Type	✘	✔	✔	✔	✔	✔	✔	✔	✘	✔
Primary vs. Secondary Cancer	--	--	--	--	✔	✔	--	--	--	--
Year	✘	✘	✘	✔	✔	✔	✔	✔	✘	✔
Ontario vs. Rest of Canada	✘	✘	✘	✔	✘	✔	✘	✔	✘	✘

IHM= In-hospital mortality; LOS= 30-day Length of stay

✔= Significant association; ✘ = Insignificant association

4.1 APPROACH AND OBJECTIVES

This section provides a detailed discussion on the current state of cancer surgeries for esophageal, pancreatic, liver, lung, and ovarian cancer surgeries across Canada. The primary objective of our analyses were: 1) To provide quantitative evidence on the impacts of regionalization activities on patient outcomes established through risk-adjusted volume-outcome associations for the five surgical procedures of interest; 2) To demonstrate the disparities across the provinces in regards to patient-based outcomes of interest; and 3) To present the temporal and geographic trends in the distribution of surgical care across the provinces, and associated burden of travel. The main outcomes of interest included in-hospital mortality, 30-day length of stay, per capita resection rates, and travel distances. In addition, the potential years of lives and the number of hospitalization days saved through consolidation to high volume centres are also presented in this section. A detailed description of data selection and statistical analysis methodologies are described in Appendix 2 and 3.

The national-level data, excluding Quebec, was extracted from the Canadian Institute of Health Information Discharge Abstract Database (DAD), which contains hospital records for in-patient admissions. Except for liver cancer, only cases with primary cancers and associated surgical procedure(s) over the 9-year period (2004-2012) were included in this analysis (See Appendix 2 for detailed inclusion criteria). Surgeon volume, surgeon specialty, and hospital volume were used as proxy measures to predict the impacts of regionalization of these complex high-risk cancer surgeries to higher volume centres. Mortality and length of hospital stay were selected as outcomes of interest due to the suitability of the datasets as well as the fact that these two outcomes are considered highly important to both patients and health care planners. Multivariate regression and survival analyses were performed to assess the adjusted risk of mortality and length of stay associated with patient and provider specific variables of interest. Geographic Information Systems (GIS) spatial mapping techniques were employed to investigate how regionalization of surgical cancer services has evolved over the study period and how this impacts patient travel times to access surgical care (Appendix 3).

Lastly, age-standardized resection rates were used to determine the differences between provinces in proportion of resected tumours. The decision to undertake surgical approach depends on cancer-specific factors (i.e. stage, extent of tumour spread), patient-related factors (age, comorbidities, or choice of treatment); however, studies have shown resection rate to be associated with provider's decision to adopt surgical treatment even in high-risk cases.[162,163] It has been speculated that any increase in resection rates could lead to improved survival.[166] Since improvements in resection rates represent an opportunity to improve survival, we present the differences in resection rates across provinces for the cancer surgeries of interest. If higher resection rates do affect survival, any inter-provincial differences in the proportion of resected cancer tumours could potentially indicate

disparities in the equitable access to high quality care. The age-standardized resection rates were calculated using the 1991 Canadian population structure as a reference population. Provincial population distributions in 2005 and 2011 were standardized and multiplied by 3 to obtain the denominator as person-years, as opposed to the annual rate(s). The numerator for resection rate calculation was the sum of surgeries taking place over in the first and last 3 years of the study cohort. The age-standardized incidence rates for esophageal, pancreatic, and lung cancers in 2010 are reported for comparison purposes. The incidence rates for ovarian and liver cancers could not be reported as all the diagnosis codes for ovarian cancer(s) used in this study and the incidence of secondary liver tumours were not available from Statistics Canada.

4.2 ANALYSIS RESULTS

Overall, differences were observed in the total number of surgeries performed for each cancer (Table 4.1). Moreover, inter-provincial differences in the proportion of surgeries for a particular cancer type were also apparent, related mainly to the variance in population density across Canada. A majority (49-52%) of procedures for all five cancers were performed in Ontario, with British Columbia and Alberta constituting the second and third highest proportions, respectively. This section will summarize the state of surgical care for each cancer type in Canada, and the results of volume-outcome association. See Appendix 4 and 5 for detailed statistical analyses.

TABLE 4.1: TOTAL NUMBER OF RESECTIONS IN CANADA (2004-2012)

Province	Esophagus (%)	Lung (%)	Liver (%)	Ovarian (%)	Pancreas (%)	Total
Alberta (AB)	311 (11.1)	2,946 (9.7)	1,241 (14.9)	2,182 (12.9)	648 (16.2)	7328
British Columbia (BC)	508 (18.0)	4,691 (15.5)	1,516 (18.2)	3,051 (18)	674 (17)	10440
Manitoba (MB)	114 (4.0)	1,986 (6.5)	345 (4.1)	895 (5.2)	164 (4.1)	3504
New Brunswick (NB)	84 (3.0)	1,518 (5)	59 (0.71)	526 (3.1)	85 (2.1)	2272
Newfoundland (NL)	29 (1.1)	455 (1.5)	155 (1.8)	362 (2.1)	80 (2.0)	1080
Nova Scotia (NS)	171 (6.1)	1,734 (5.7)	505 (6.0)	731 (4.3)	181 (4.5)	3322
Ontario (ON)	1,472 (52.3)	15,732 (52)	4,315 (51.7)	8,340 (49.2)	2,053 (51.5)	31912
Prince Edward Island (PEI)	*	*	*	62 (0.4)	-- --	69

Saskatchewan (SK)	119 (4.3)	1,218 (4.02)	194 (2.3)	800 (4.7)	105 (2.6)	2436
Total	2,810	30,284	8,333	16,949	3,990	62366

**numbers suppressed (<5 surgeries)*

4.2.1 ESOPHAGEAL CANCER SURGERY

Esophageal resections had the smallest annual case volume among the five cancers of interest. A total of 2810 relevant esophageal cancer resections were performed in 71 hospitals across Canada (2004-2012). The number of institutions performing esophageal resections declined over time, mainly led by a 50% reduction across Ontario (Figure 4.2.1a). However, the annual number of esophageal resections stayed relatively stable during this time period, increasing only 6.4% (Table 4.2.1a). Figure 4.2.1b depicts annual provincial volumes and changes in the number of procedures over time, with case volumes only minimally increasing over the study period and differing only slightly between the provinces. Due to the small annual case load, the median hospital volume was 12 esophagectomies per year (Interquartile range [IQR]=13), and median annual surgeon volume was 5 esophagectomies [IQR=6]. Although the proportion of specialist surgeons varied between provinces and over the years, thoracic surgeons performed nearly 2/3rd of all esophagectomies across Canada between 2004 and 2012. The mean patient age was 64.1 (Standard Deviation [SD]=10.2) years, with a majority (79%) being male.

TABLE 4.2.1A: TOTAL NUMBER OF RESECTIONS FOR ESOPHAGEAL CANCER IN CANADA (2004-2012)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
AB	33	27	22	27	37	34	37	45	49	311
BC	51	48	44	59	51	63	64	62	66	508
MB	14	13	14	13	15	9	9	11	16	114
NB	*	9	8	7	10	14	11	7	13	84
NL	*	*	*	*	*	*	*	*	*	29
NS	21	20	18	25	24	15	12	22	14	171
ON	173	169	160	157	145	172	150	185	161	1472
PEI	*	*	*	*	*	*	*	*	*	*
SK	11	13	12	13	12	13	16	17	12	119
Canada	**314**	**301**	**283**	**304**	**294**	**323**	**303**	**354**	**334**	**2810**

** Number suppressed if number of surgeries <5*

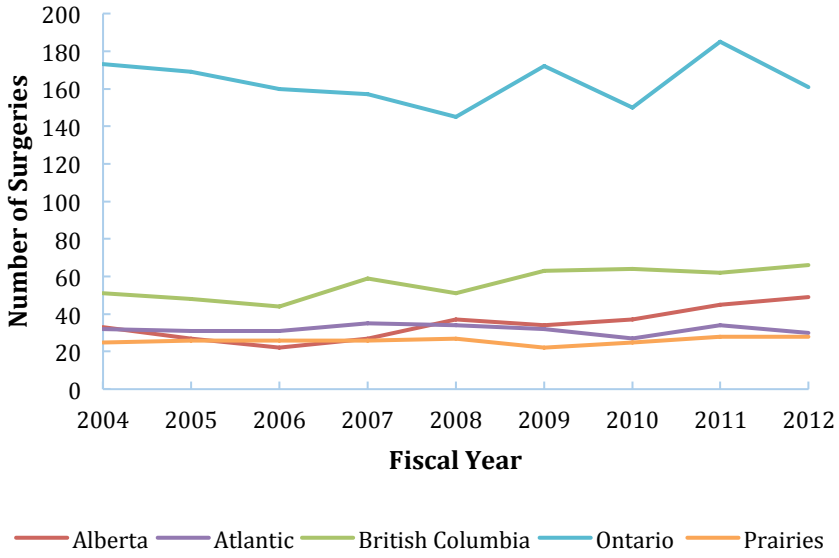


Figure 4.2.1a: Number of esophageal cancer surgeries, by province (2004-12)

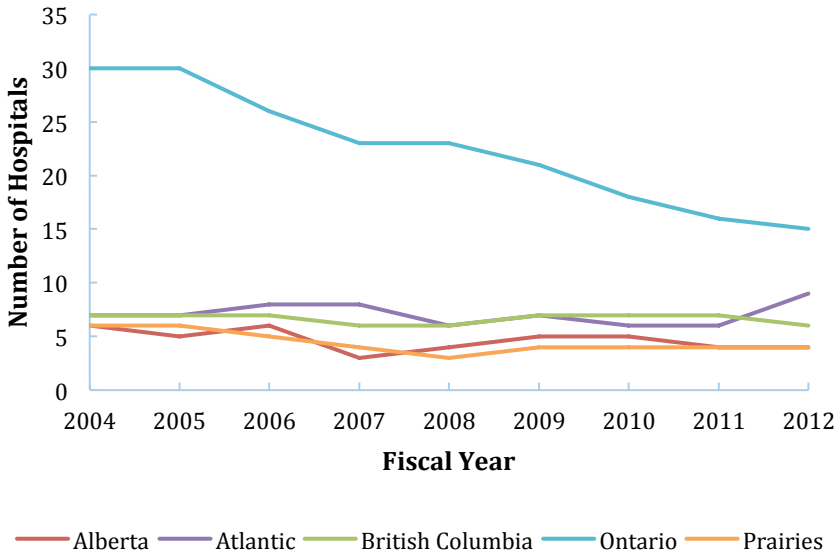


Figure 4.2.1b: Number of institutions performing esophageal cancer surgeries, by province (2004-12)

Travel Distance

The median number of kilometers travelled by the patients to the surgical centres increased over time, with a reduction in the number of facilities providing esophageal resections. The difference in median travel distances from 2004-06 to 2010-12 is presented in Table 4.2.1b. A geographic representation of changes in distribution and number of institutions between these two time periods is presented in Figures 4.2.1c and 4.2.1d.

The magnitude of change in additional travel distances varied by province; with Newfoundland and Saskatchewan showing the highest increase. However, the smaller sample size in Newfoundland may jeopardize the validity of these results. On the contrary, a reduction in median kilometers travelled by the patients was observed in Manitoba and British Columbia over the two time periods (24 and 5 kilometers, respectively). As expected, the provinces with the highest increase in median number of kilometers also depicted a reduction in proportion of patients within one hour travel distance (Table 4.2.1b). In Ontario an additional 6 (median) kilometers were added to the patient journey as a result of a 50% reduction in number of facilities. Between fiscal years 2010-12, 61% of patients were still within a one hour travel distance from the surgical centre, down 3% from 2004-06.

It should be noted that the provinces differ in population densities, hence, the relative proportions of populations within 1 hour of travel distance is expected to vary. The relative differences across different disease sites within the same province might serve as a better indicator of disparities in structures of care for difference surgical procedures. Intra-provincial differences in patient travel times for different surgeries are presented in Chapter 5.

TABLE 4.2.1B: CHANGE IN MEDIAN TRAVEL DISTANCES FROM 2004-06 TO 2010-12

Province	**2004-06**		**2010-12**		**Change from 2010-12 to 2004-06**
	Median Travel Distance in kilometers [IQR]	*% in 1 hour travel time*	*Median Travel Distance in kilometers [IQR]*	*% in 1 hour travel time*	*Difference in Median Travel Distances (kilometers)*
AB	15 [81]	66	47 [160]	49	+32
BC	33 [95]	50	28 [88]	57	-5
MB	38 [68]	54	14 [104]	53	-24
NB	19 [54]	68	20 [41]	65	+1
NL	8 [111]	55	146 [442]	33	+137
NS	63 [160]	46	93 [282]	44	+29
ON	25 [81]	64	31 [79]	61	+6
SK	74 [221]	44	162 [229]	29	+87

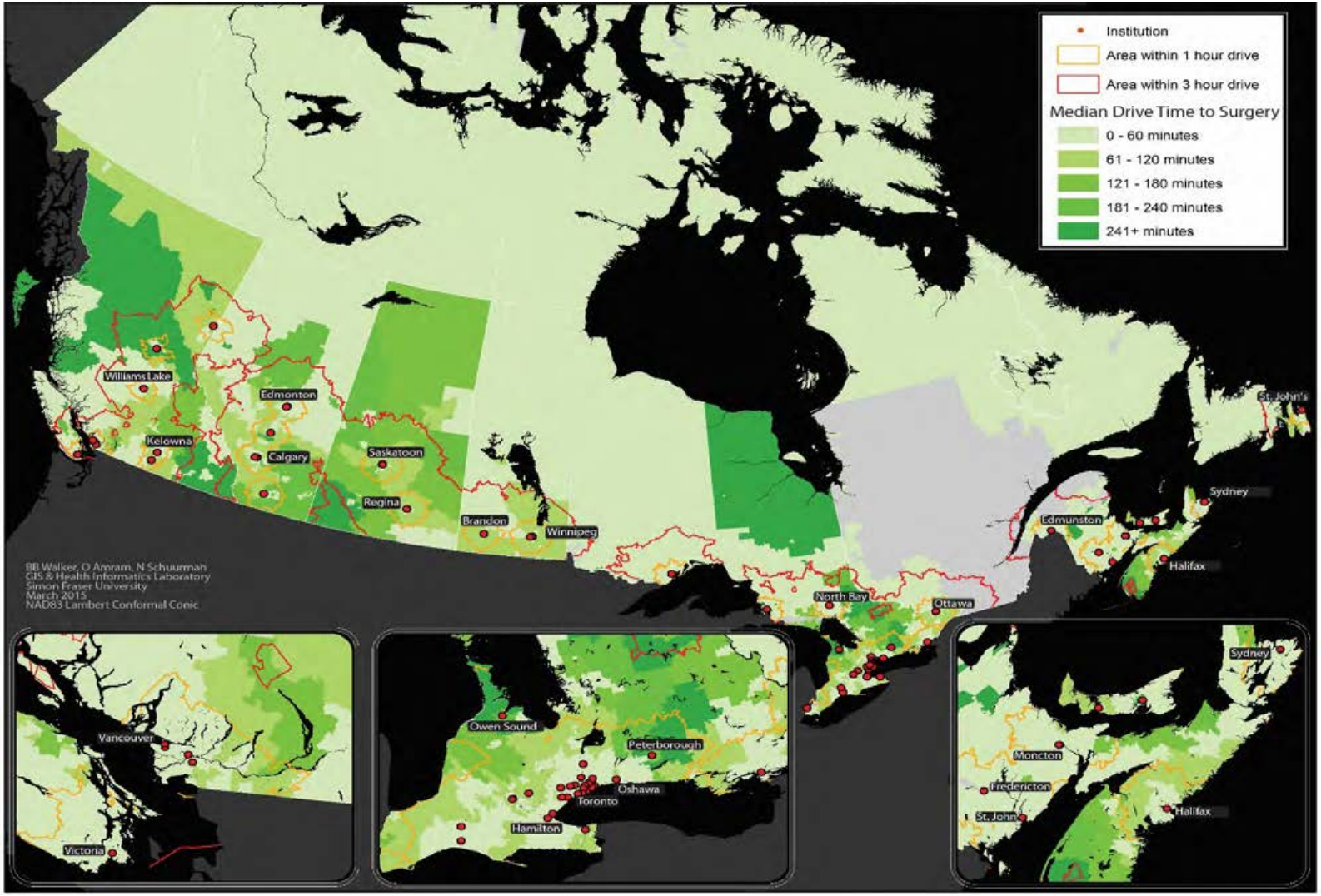


Figure 4.2.1c: Patient travel times and pan-Canadian distribution of hospitals performing esophageal cancer surgeries, 2004-06

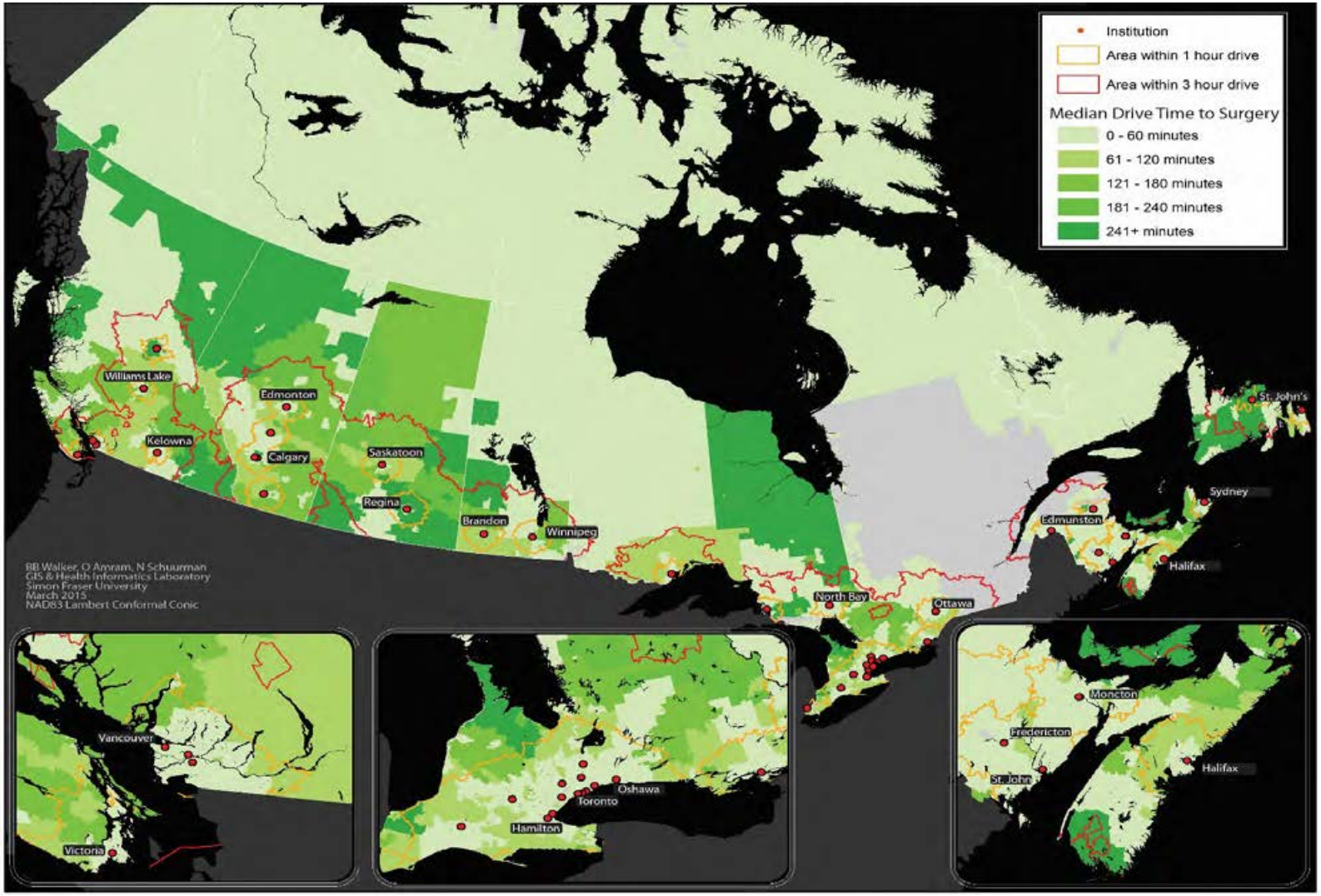


Figure 4.2.1d: Patient travel times and pan-Canadian distribution of hospitals performing esophageal cancer surgeries, 2010-12

Resection Rate

Figure 4.2.1e depicts resection rates over time in comparison with the age-adjusted incidence rates. Overall, the minimal variations in age-standardized resection rates were observed between provinces in 2010-12 fiscal years. The rates varied from 3.9 (per 100,000) in Saskatchewan to 1.7 (per 100,000) in Newfoundland in the 2010-12 fiscal years. Apart from Manitoba (2.7 per 100,000), the resection rates for other provinces were higher than 3 resections per capita. However, the rates varied over the year within the provinces. For instance, an increase in resection rates occurred in Alberta, British Columbia, New Brunswick, and Saskatchewan between the first three-year interval (2004-2006) and the later interval in 2010-2012. The rates of esophageal resection stayed stable in Ontario over the two time periods. Newfoundland had the lowest rates of 2 resections per capita among all the provinces. The provincial resection rates observed over time do not depict a clear association with relative 9-year mortality rates reported in Figure 4.2.1g. However, the resections rates were lower than the incidence rates for Manitoba, New Brunswick, Nova Scotia, and Ontario. The implications of such differences on survival rates and quality of care need further investigation.

Figure 4.2.1e: Age-standardized resection rates per 100,000 populations for esophageal cancer surgeries

In-Hospital Mortality

The overall in-hospital mortality for esophagectomy cases over the 9-year period was 5.6%, declining from 6.3% in 2004 to 3.3% in 2012 (Figure 4.2.1f). As expected, there were differences between provinces in the 9-year average mortality rate, even after adjusting for age differences among the provinces (Figure 4.2.1g). Manitoba, New Brunswick, Ontario, and Saskatchewan had 9-year mortality rates above the national average, with other

provinces such as Newfoundland markedly lower. It must be noted that these age-adjusted mortality rates do not consider the number of patients who opt-out of surgery, are more highly staged and thus ineligible for resection, or experience a greater number of co-morbidities. More significantly, the rates cannot consider the effect of even a small number of deaths in a small sample, as would be the case with Newfoundland. These factors may influence the reported mortality rates in esophageal cancer, but also in the other cancer sites investigated in this report.

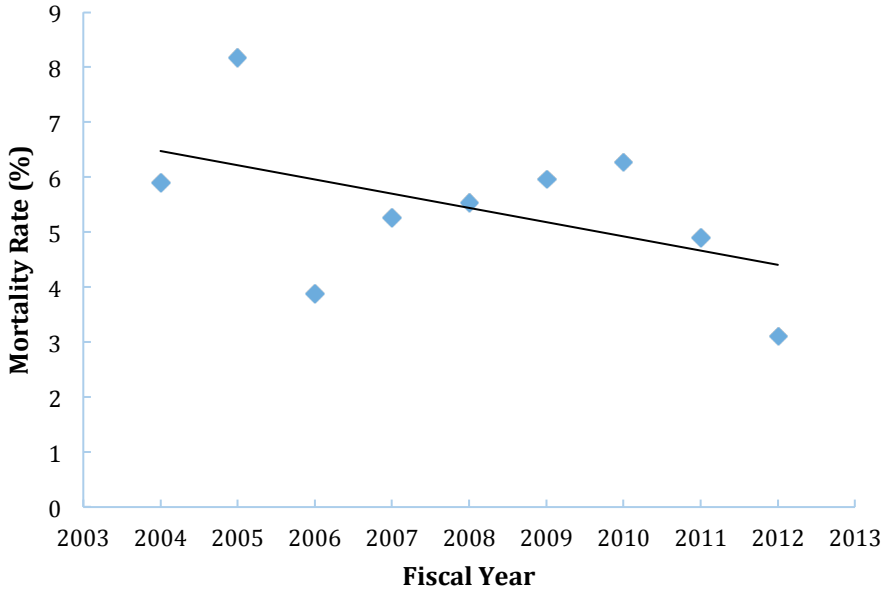


Figure 4.2.1f: Annual age-adjusted mortality rates for esophageal cancer surgeries (2004-12)

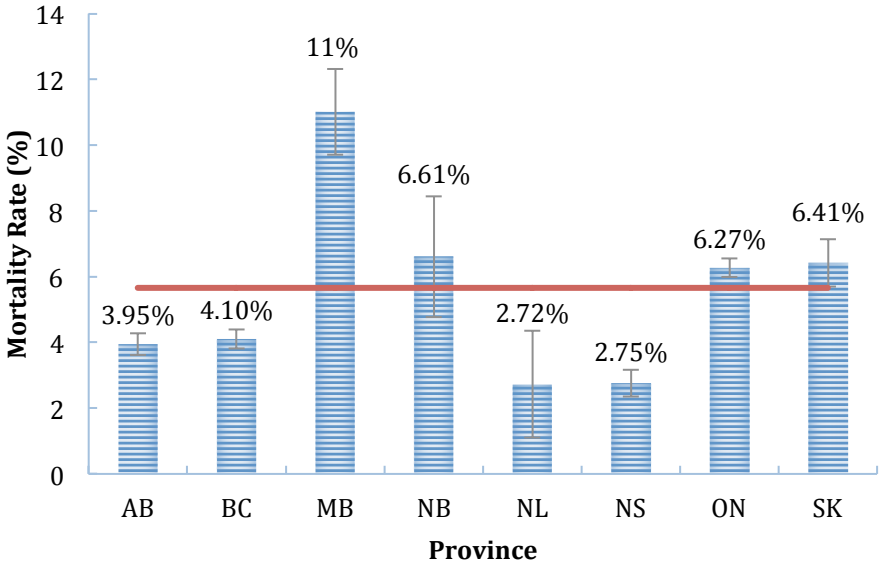


Figure 4.2.1g: Age-adjusted mortality rates for esophageal cancer surgeries (2004-12)

In univariate analysis, hospital volume, surgeon volume and specialty were all associated with differences in the in-hospital mortality rate. Figure 4.2.1h, demonstrates a linear reduction in observed mortality rates with an increase in annual hospital volume. In multivariate analysis, hospital volume was significantly associated with reduction is risk of mortality, after controlling for the effect of patient-related covariates, surgeon volume, specialty, and significant interactions between provider volume and specialty (see Appendix 4). A significant effect of hospital volume on risk of mortality persisted after controlling for provincial variations in the model. Among the non-modifiable factors, patient age and co-morbidity score significantly predicted the risk of in-hospital mortality. Procedural type (open vs. minimally invasive resection), and patient gender did not significantly predict the risk of in-hospital mortality.

Surgeon volume or specialty was insignificantly associated with mortality risk after controlling for hospital volume and random differences between hospitals. A strong interaction between provider volume and surgeon specialty was also observed, *further highlighting the complexity of volume-outcome association.* It also supports the premise that improved outcomes at high volume hospitals could be the result of a combination of factors including hospital volume, surgeon volume and surgeon specialty. Factors including staff training and access to advanced treatment measures could not be accounted for in present data. There were no differences in risk of mortality between Ontario and rest of Canada after controlling for other factors in the model.

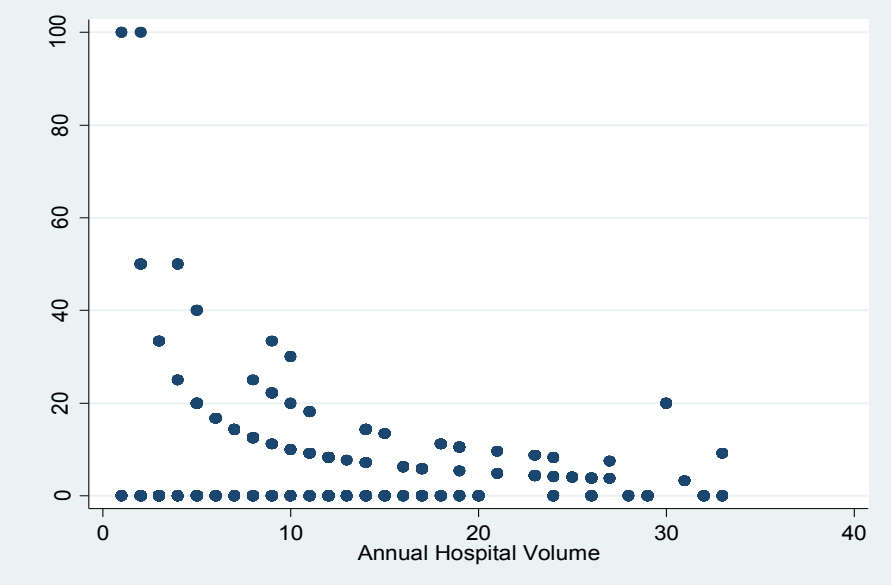


Figure 4.2.1h: Annual hospital volume and mortality rate for esophageal cancer surgeries (2004-12)

- ***The impact of hospital volume on the risk of in-hospital mortality was most pronounced for esophageal cancer. In a simplistic model, every 10 case increase in hospital volume predicted a risk reduction of in-hospital mortality of 21%.***

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, theoretically a total of 30 additional lives could have been saved after esophageal cancer surgeries in Canada (2004-12).***

Length of Stay

The overall median length of stay for esophageal surgeries over the 9-year period was 13 days [IQR=12]. In spite of slight variations over the years, the median length of stay has been reduced by one day across Canada from 2004 to 2012 (Table 4.2.1b). Similarly, provincial differences were apparent as well, with New Brunswick and Saskatchewan having the highest median length of stay at 16 days and British Columbia with the lowest at 12 days (Table 4.2.1c). Without accounting for any other differences between provinces affecting length of stay, this difference implies a costly additional 476 hospital days for Saskatchewan, and 336 for New Brunswick relative to British Columbia over this time period. While differences in discharge rate at different time period are evident for open procedures, the relative differences between low and high volume hospitals at each period appear constant (Figure 4.2.1i).

TABLE 4.2.1C: MEDIAN LENGTH OF STAY

Province	Median length of stay [IQR]
AB	15 [10]
BC	12 [11]
MB	14 [11]
NB	16 [20]
NL	14 [3]
NS	13 [10]
ON	13 [12]
SK	16 [13]

TABLE 4.2.1B: MEDIAN LENGTH OF STAY IN CANADA, BY YEAR

	Fiscal Year								
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Median length of stay [IQR]	13 [14]	15 [13]	14 [12]	14 [13]	13 [12]	13 [12]	13 [12]	13 [10]	12 [10]

In survival analysis, patient age, co-morbidities, open procedures, and male patients were significantly associated with a risk of longer length of stay. The survival model is presented in Appendix 5. Surgeon specialty was not significantly associated with length of stay. Higher surgeon volume was significantly associated with a shorter length of stay for those discharged alive, with this association marginally significant for hospital volume. There were also no differences between Ontario and rest of Canada on length of hospital stay.

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, a median of 407 hospital days could potentially have been saved annually across Canada for esophageal cancer surgeries (2004-12).***

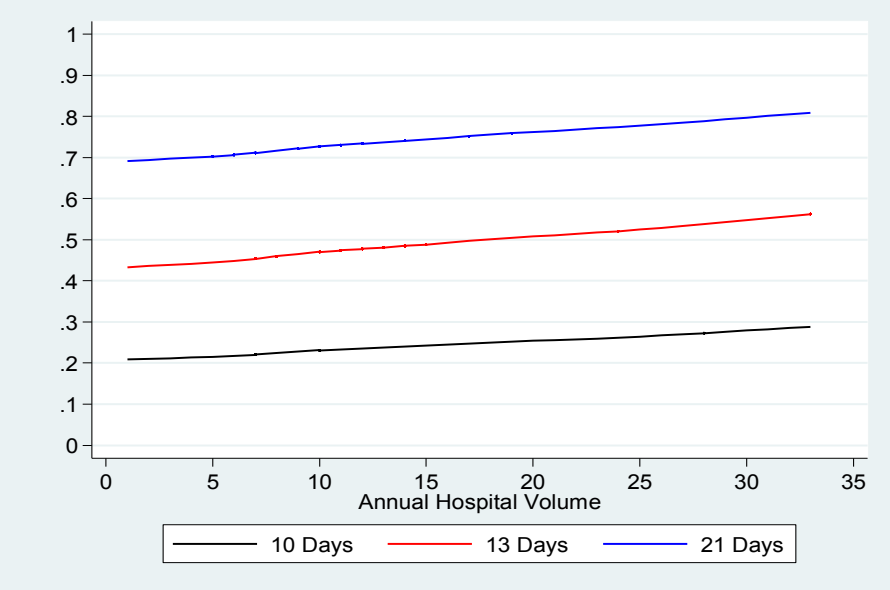


Figure 4.2.1i: Predicted discharge rate for open esophagectomy in Canada (2004-12)

4.2.2 PANCREATIC CANCER SURGERY

In the period spanning 2004 to 2012, 3990 relevant pancreatic resections were performed in 92 hospitals across Canada. The mean age of patients was 63.7 (SD=11.6) years, with 51% of patients being male. The median hospital volume was 23 resections per year [IQR=30], and median surgeon volume was 8 resections annually [IQR=8]. The annual number of pancreatic cancer surgeries increased 77%, from 337 procedures in 2004 to 599 in 2012 (Figure 4.2.2a). An increase in number of procedures was observed in Ontario, Alberta, Manitoba, and British Columbia (Table 4.2.2a). At the same time, the number of institutions performing surgeries decreased from 56 in 2004 to 39 in 2012 (Figure 4.2.2b). It is interesting to note that a 50% reduction in the number of institutions performing pancreatic resections was observed in Ontario and New Brunswick (26 to 13; and 6 to 3 respectively], potentially demonstrating active regionalization efforts in Ontario and the apparent consolidation of surgical cancer services in New Brunswick.

TABLE 4.2.2A: NUMBER OF PANCREATIC CANCER SURGERIES IN CANADA, BY YEAR AND PROVINCE (2004-12)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
AB	47	60	56	45	79	73	85	92	111	648
BC	60	76	73	87	76	72	55	83	92	674
MB	13	7	16	16	13	19	33	16	31	164
NB	16	14	7	11	*	9	6	11	9	85
NL	14	6	7	*	6	14	7	8	13	80
NS	21	13	28	14	24	25	22	18	16	181
ON	155	209	200	213	199	238	235	288	316	2053
SK	11	11	13	10	17	6	9	17	11	105
Canada	**337**	**396**	**400**	**401**	**416**	**456**	**452**	**533**	**599**	**3990**

**Number suppressed if number of surgeries ≤5*

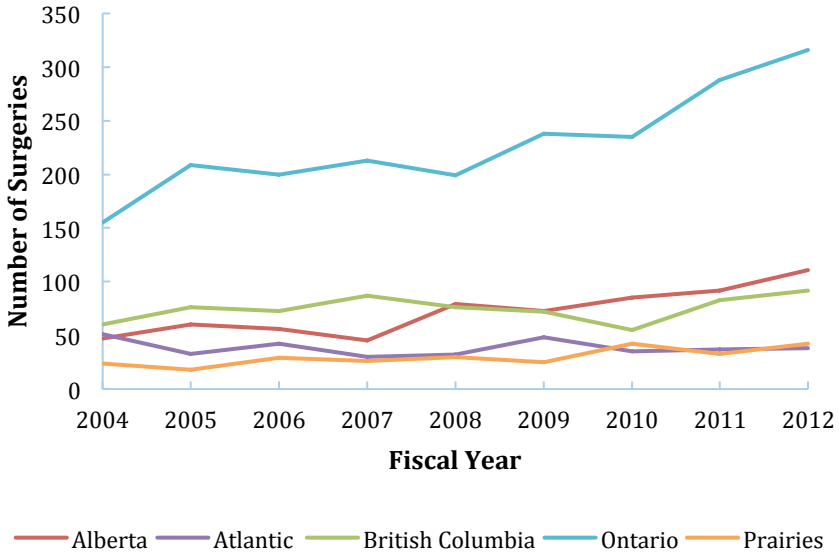


Figure 4.2.2a: Number of pancreatic cancer surgeries, by province (2004-12)

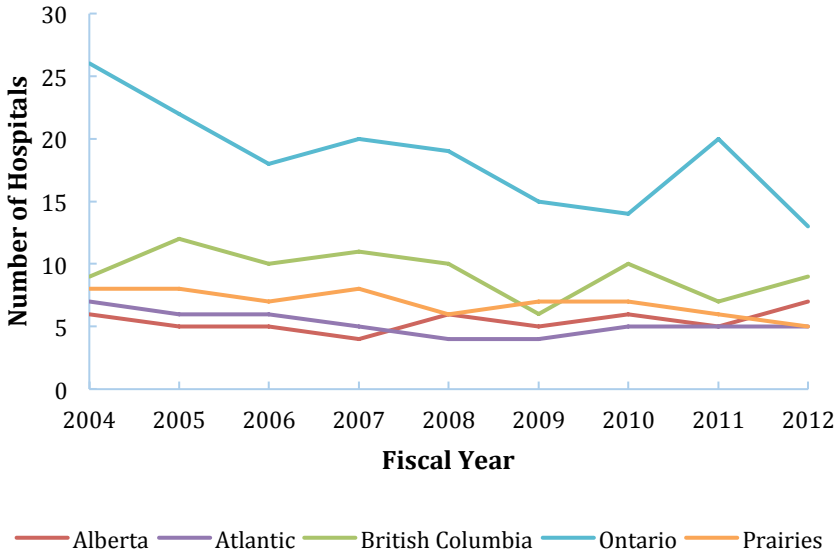


Figure 4.2.2b: Number of institutions performing pancreatic cancer surgeries, by province (2004-12)

The outcomes of surgery also depend on complexity of surgical approach. Among the three surgical approaches, Whipple procedures (pancreaticoduodenectomy) were performed in the majority of cases (72%), with open distal pancreatectomy accounting for a remaining 25% of procedures. A minimally invasive approach was adopted for only 2.8% of the procedures.

Travel Distance

Overall, a reduction in the proportion of population within one hour travel distance of pancreatic surgical cancer care was noticed for all provinces, albeit of different magnitudes. Median travel distances increased in all provinces when comparisons were made between first and last three fiscal years (Table 4.2.2b). The greatest increase was found in Newfoundland, with median of 193 extra kilometers travelled by the patients to receive pancreatic cancer surgery. In Ontario, the 50% reduction in number of institutions performing pancreatic surgeries resulted in a median of 5 additional kilometers, associated with 3% lower proportion of population within 1 hour travel distance. The reduction in the number of facilities in New Brunswick affected the median travel distance, but not the proportion of population within one hour of travel time. The remaining provinces showed changes in patients traveling more than an hour without any major changes in structure of care i.e. facility distribution. Figures 4.2.2c and 4.2.2d can be used to visualize the geographic distribution of facilities providing pancreatic cancer surgical care in 2004-06 and 2010-12.

TABLE 4.2.2B: CHANGE IN MEDIAN TRAVEL DISTANCES FROM 2004-06 TO 2010-12

Province	2004-06		2010-12		Change from 2010-12 to 2004-06
	Median Travel Distance in kilometers [IQR]	*% in 1 hour travel time*	*Median Travel Distance in kilometers [IQR]*	*% in 1 hour travel time*	*Difference in Median Travel Distances (km)*
AB	17 [128]	64	22 [165]	57	+5
BC	17 [59]	60	28 [59]	57	+11
MB	10 [104]	64	16 [94]	59	+6
NB	60 [105]	35	102 [146]	35	+42
NL	79 [400]	44	272 [405]	25	+194
NS	43 [164]	47	115 [292]	36	+72
ON	27 [73]	64	32 [76]	61	+5
SK	118 [220]	43	155 [204]	35	+37

Resection Rate

Overall, a majority of the provinces reported an increase in adjusted resection rates for pancreatic cancer over time, except from New Brunswick and Newfoundland. Figure 4.2.2e shows that Alberta had the highest resection rate for pancreatic cancer surgeries, increasing from 4.5 to 7.8 resections per capita over the two time periods. Manitoba and Ontario also saw an increase in resection rates over time, 2.9 and 1.9 (per, 100,000) respectively. There was substantial variation between the highest and lowest resection rates between provinces in 2010-12. In quantitative terms, the rate varied from 3.4 (per 100,000) in Newfoundland to 7.8 (per 100,000) in Alberta. Although the relative differences varied, the incidence rates for pancreatic cancer were higher than the observed resection rates for all the provinces.

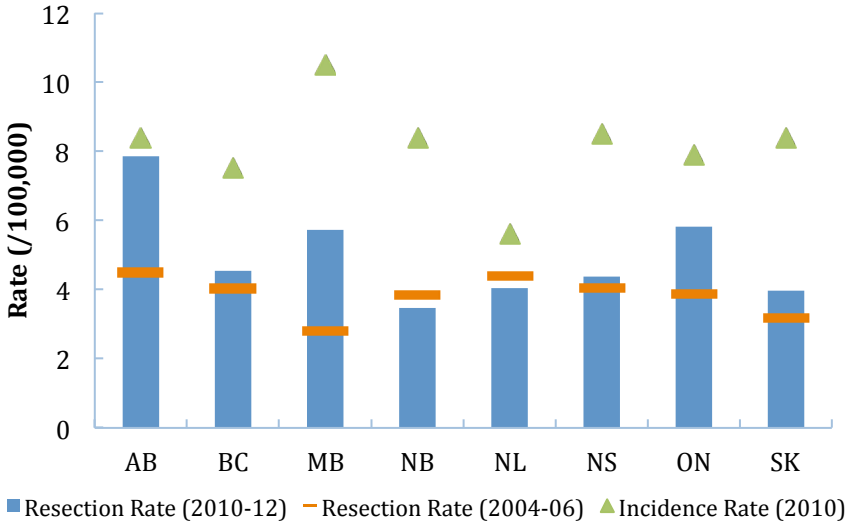


Figure 4.2.2e: Age-standardized resection rates per 100,000 population for pancreatic cancer surgery

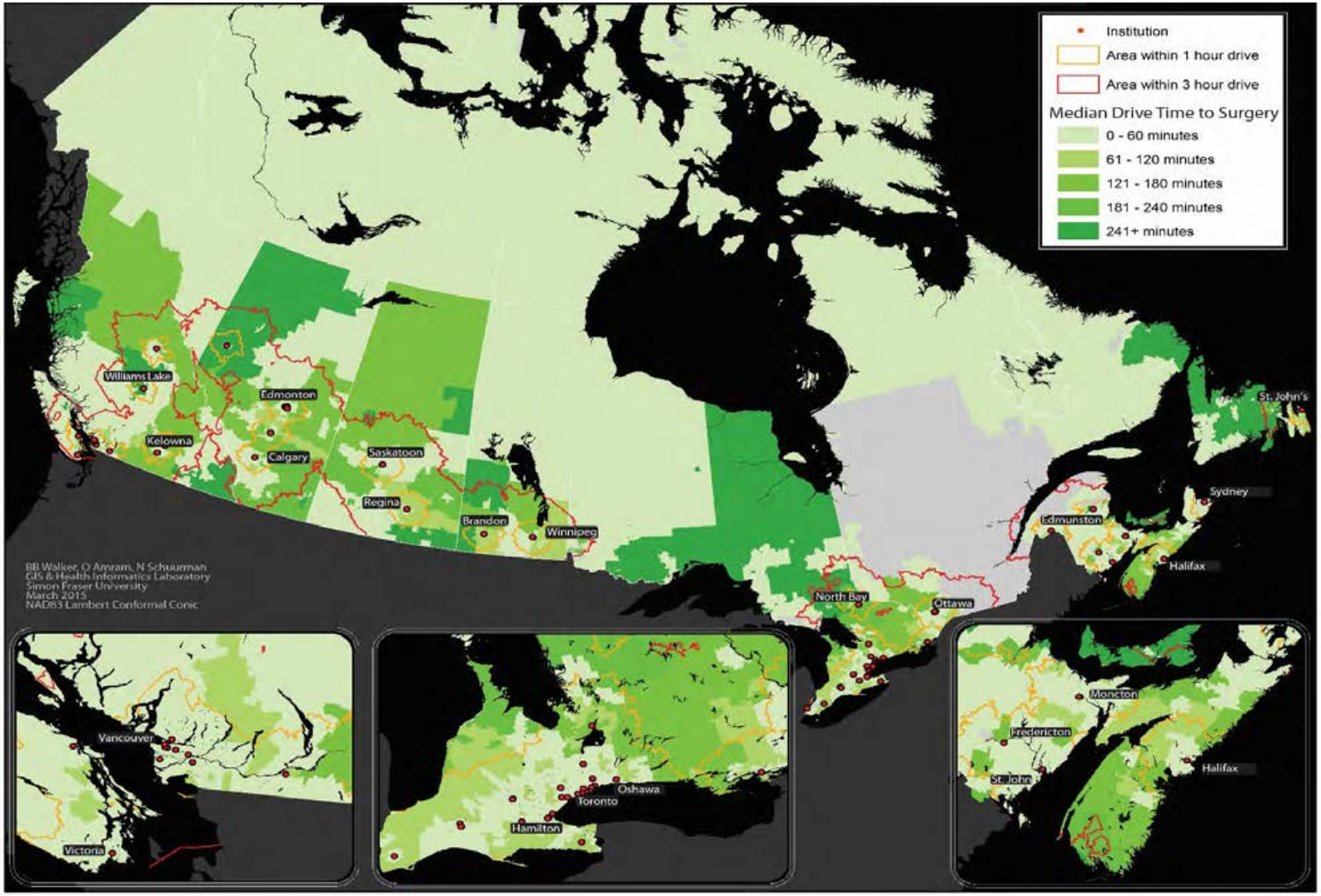


Figure 4.2.2c: Patient travel times and pan-Canadian distribution of hospitals performing pancreatic cancer surgeries, 2004-06

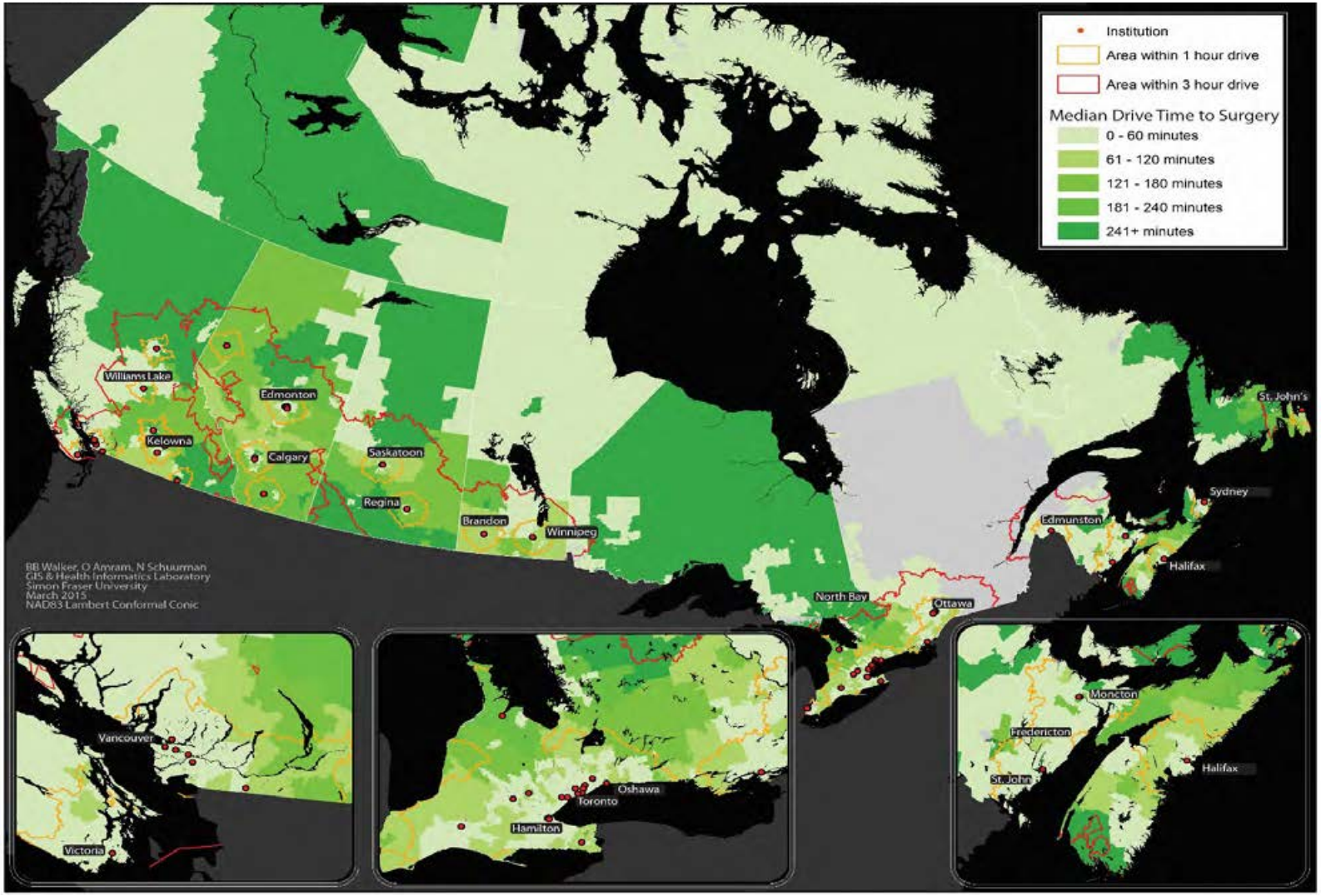


Figure 4.2.2d: Patient travel times and pan-Canadian distribution of hospitals performing pancreatic cancer surgeries, 2010-12

In-Hospital Mortality

The overall in-hospital mortality rate after pancreatic resection for malignant indications over a 9-year period was 3.7%. Marked variations in annual mortality rates were observed over time, with the lowest annual mortality rate in Canada for pancreatic cancer surgeries found to be 2% in 2011 and 6% in 2005 (Figure 4.2.2f). In addition to variations in mortality rate observed over time, provincial differences in 9-year average mortality rates were also apparent. Alberta, Manitoba, Nova Scotia, and Saskatchewan had rates higher than the national 9-year average (Figure 4.2.2g).

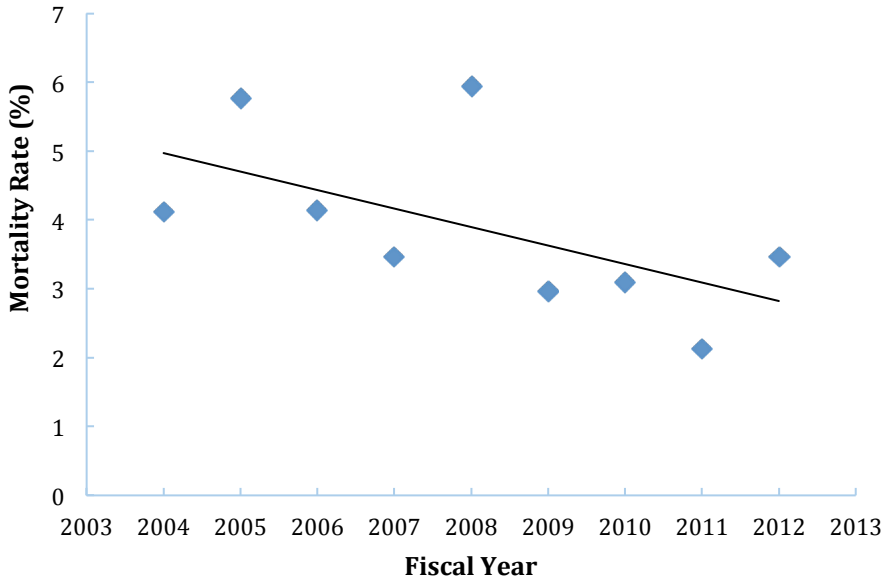


Figure 4.2.2f Annual age-adjusted mortality rates for pancreatic cancer surgeries (2004-12)

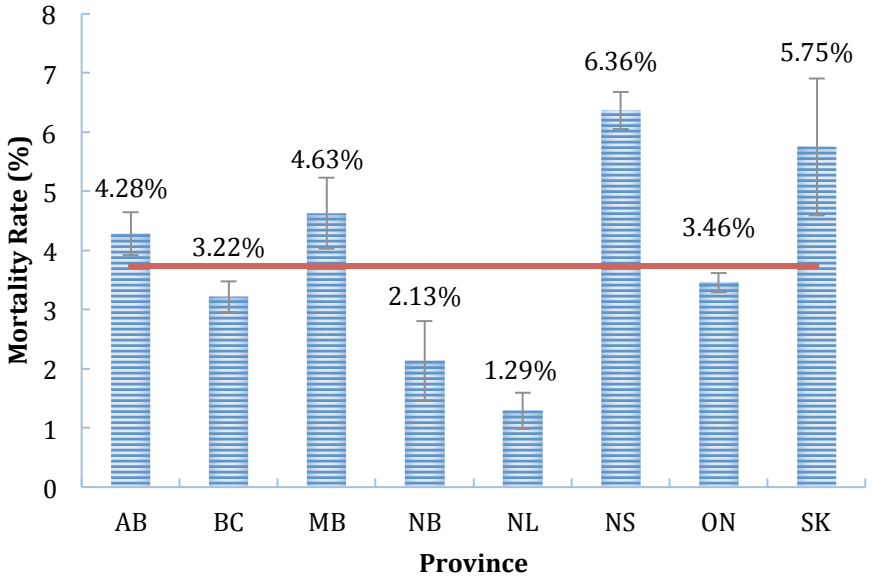


Figure 4.2.2g: Age-adjusted mortality rates for pancreatic cancer surgeries (2004-12)

According to the multivariate regression model, the risk of in-hospital mortality for pancreatic cancer resections increased with increasing age and co-morbidity score (Appendix 4). Gender and year did not significantly predict the risk of in-hospital mortality. A Whipple procedure was associated with a significantly higher risk when compared to distal pancreatectomy.

In univariate analysis, hospital volume was significantly associated with the rate of mortality (p=0.003), but not surgeon volume. Figure 4.2.2h represents a simplistic view of the association between increasing annual hospital volume and mortality rate for pancreatic cancer resections in Canada. A steeper reduction in mortality rate is apparent with an initial increase in volume, with the trend stabilizing around 40 procedures per year. Hospital volume was a significant predictor of mortality in the multivariate regression model, after controlling for random hospital effect and provincial variations. Surgeon volume was only significantly associated with mortality risk without hospital related factors in the model. There were no significant differences in risk of mortality between Ontario and rest of Canada.

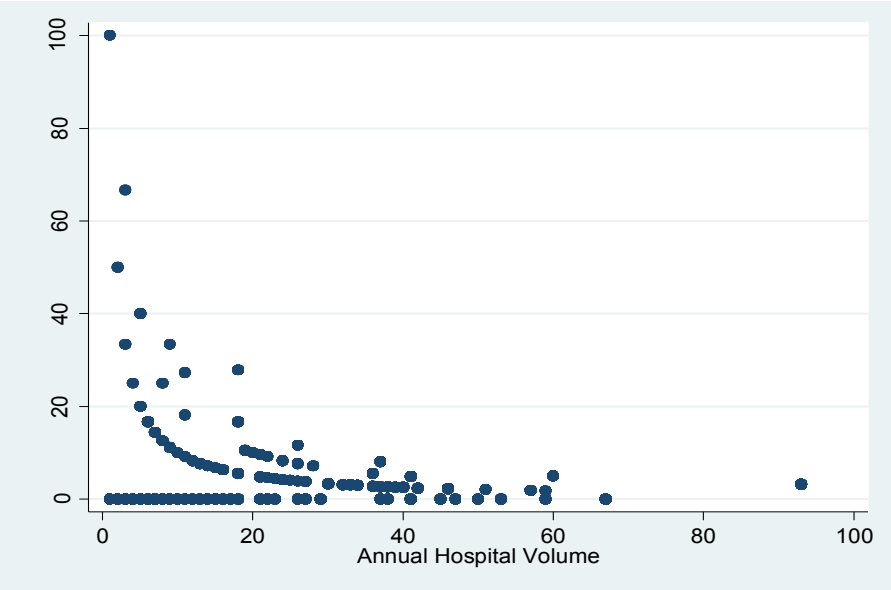


Figure 4.2.2h: Annual hospital volume and mortality rate (%) for pancreatic cancer surgeries (2004-12)

- ***According to the model, an annual increase in 10 cases in a given hospital predicted a 22% decrease in the risk of in-hospital mortality after controlling for the influence of covariates and random clustering effects of individual hospitals.***

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, theoretically a total of 89 additional lives could have been saved after pancreatic cancer surgeries in Canada (2004-12).***

Length of Stay

The median length of stay after a pancreatic resection in Canada during 2004 to 2012 was 11 days [IQR=9]. Over the course of nine years, the median length of stay decreased from 13 to 12 days in Canada (Table 4.2.2b). The provincial median hospital days ranged from 10 in Ontario to 15 in Saskatchewan with a majority of provinces having values between 13 and 14 days (Table 4.2.2c). An increase in discharge rate with increasing volume for both Whipple procedure and distal pancreatectomy resection types at median length of stay is depicted in Figure 4.4.2i. Figure 4.2.2j a) and b) demonstrate differences in predicted discharge rates between procedures at different points in time.

TABLE 4.2.2C: MEDIAN LENGTH OF STAY

Province	Median Length of Stay [IQR]
AB	12 [10]
BC	13 [10]
MB	14 [11]
NB	14 [11]
NL	13 [16]
NS	13 [14]
ON	10 [8]
SK	15 [16]

Survival analysis confirmed a statistically significant association between patient age and co-morbidity score with a longer length of stay (Appendix 5). There were no statistically significant differences in length of stay between males and females. As expected, Whipple procedures, being more complex, had longer length of hospital stay as compared to distal pancreatectomy. Furthermore, the requirement of additional organ resections (i.e. gall bladder, bowel resections) also predicted a higher number hospitalized days. The year-to-year reductions in length of stay (Table 4.2.2b) were also confirmed after controlling for the effect of other covariates. Both hospital and surgeon volumes were significantly associated with shorter length of stay. Moreover, patients in Ontario also had higher chance of early discharge as compared to rest of Canada.

TABLE 4.2.2B: MEDIAN LENGTH OF STAY IN CANADA, BY YEAR

	Fiscal Year								
	2004	2005	2006	2007	2008	2009	2010	2011	2012
Median Length of Stay [IQR]	13 [10]	13 [11]	12 [11]	11 [11]	12 [8]	11 [10]	11 [8]	10 [8]	10 [9]

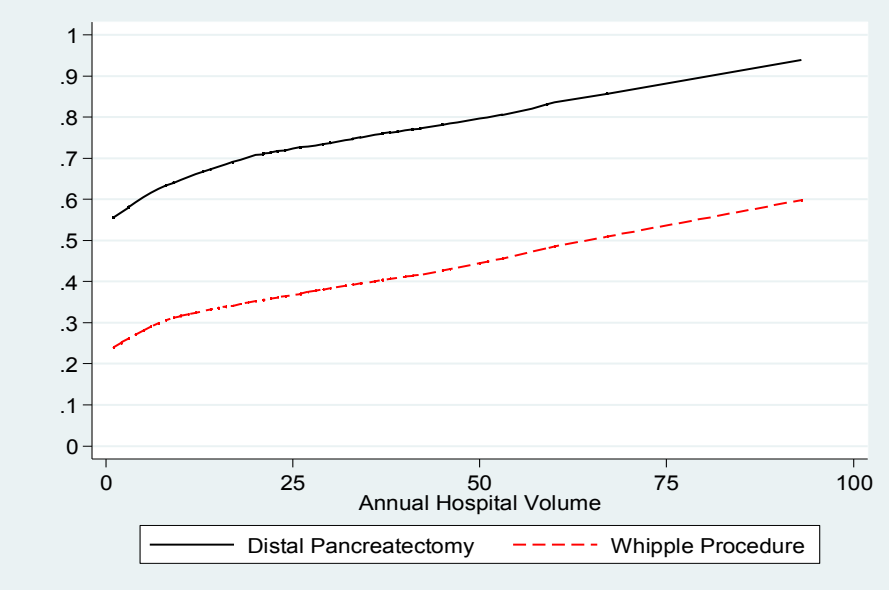


Figure 4.2.2i Predicted discharge rate 11 days after pancreatic cancer procedures (2004-12)

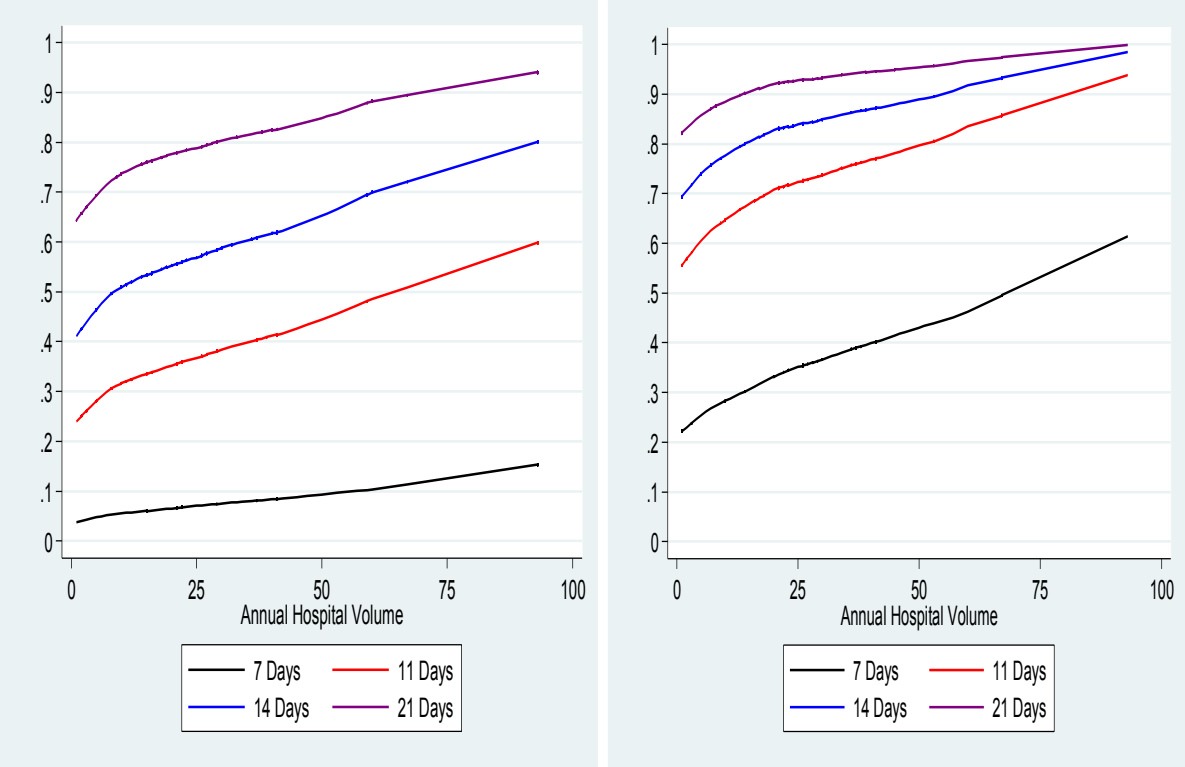


Figure 4.2.2j. Predicted discharge rate after a. Whipple Procedure b. Open Distal Pancreatectomy (2004-12)

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, a median of 725 hospital days could potentially have been saved annually across Canada for pancreatic cancer surgeries.***

4.2.3 LIVER CANCER SURGERY

Liver cancer had the third largest surgical volume among the five high-intensity cancer types studied. Overall, a total of 8083 liver resections were performed on patients with mean age of 62 (SD=11.7) years. Primary liver cancers constituted 24% of all procedures, while the remaining procedures were performed for secondary liver tumours. A total of 118 institutions performed liver surgeries over the 9-year period across Canada. As the annual number of surgeries increased 82%, the number of hospitals performing these resections decreased from 61 in 2004 to 42 in 2012. An increase in number of procedures was observed in all provinces except New Brunswick and Saskatchewan (Table 4.2.3a, and Figure 4.2.3a). Overall, the shift in the number of facilities over time was less pronounced than that observed for esophageal and pancreatic cancer surgeries (Figure 4.2.3b). A systematic shift in the number of facilities performing liver resections from 2004 to 2012 was evident in Manitoba (4 facilities to 1) and Ontario (29 centres to 20). Both of these provinces report good mortality rates and length of hospital stay relative to the pan-Canadian mean, which appears to demonstrate a positive benefit to these regionalization efforts. In the remaining provinces, the annual fluctuation in the number of facilities appeared to be a result of institutions undertaking a small liver surgical caseload (≤2/year). Among the 118 institutions providing liver resection over 9-year period, the median hospital volume was 61 resections per year [IQR=88]. The number of physicians performing liver resections stayed relatively constant over the years (119 in 2004 to 117 in 2012) with a median surgeon volume of 20 resections per year [IQR=18].

There are two types of resections for liver cancers: open and minimally invasive. A majority (93%) of resections were open procedures. Over the years, a shift towards minimally invasive procedures has been observed. In 2004, only 1% of minimally invasive procedures were performed, while this number has increased to about 11% in 2012 (Figure 4.2.3c). Minimally invasive procedures had a lower mortality rate (1.32%) as compared to open procedures (3.1%) over the study period.

TABLE 4.2.3A: NUMBER OF LIVER CANCER SURGERIES IN CANADA, BY YEAR AND PROVINCE

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
AB	116	109	94	102	130	137	153	176	224	1241
BC	121	147	155	147	141	181	175	228	221	1516
MB	19	17	33	28	44	39	43	67	55	345
NB	12	7	5	1	6	8	7	7	6	59
NL	15	15	13	9	23	17	13	21	29	155
NS	42	49	52	41	48	70	68	64	71	505
ON	347	387	418	434	468	511	505	607	638	4315
SK	20	14	25	22	23	18	21	31	20	194
Canada	692	745	796	784	883	981	985	1202	1265	8333

**Number suppressed if number of surgeries ≤5*

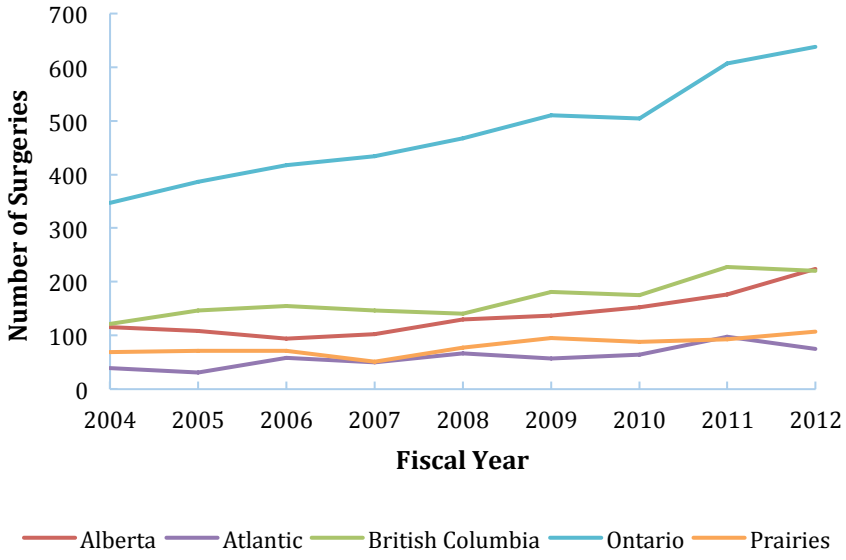


Figure 4.2.3a: Number of liver cancer surgeries, by province (2004-12)

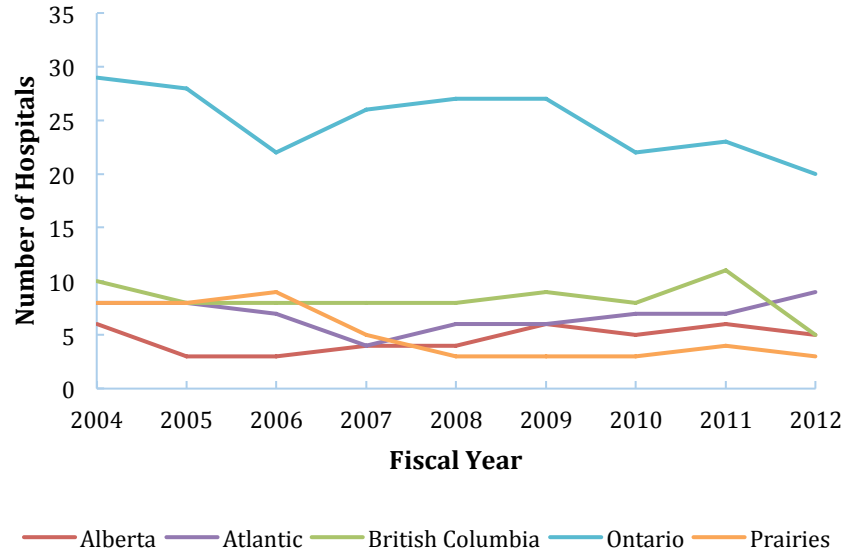


Figure 4.2.3b: Number of institutions performing liver cancer surgeries, by province (2004-12)

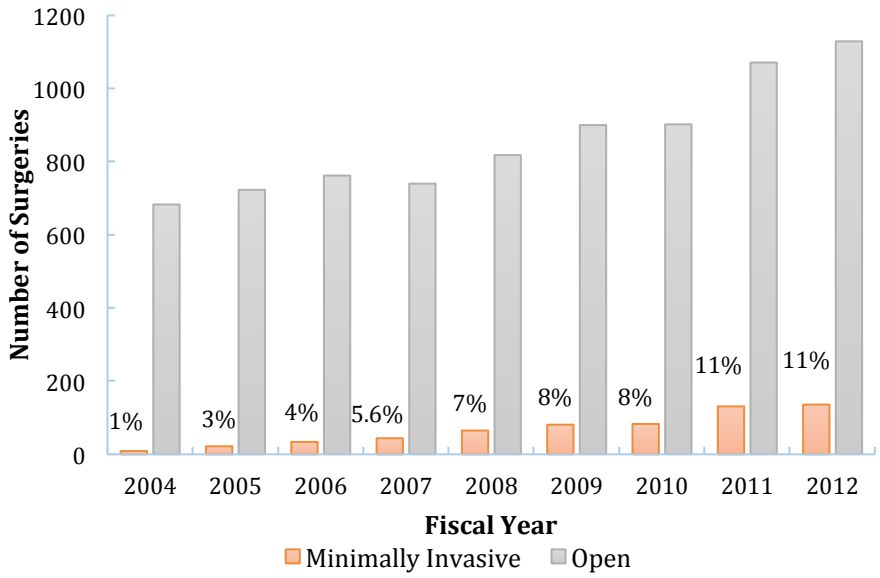


Figure 4.2.3c: Shift in liver cancer procedures in Canada (2004-12)

Travel Distances

The change in the number of institutions performing liver resections was least pronounced for liver cancer over time among the five cancer types of interest (Figure 4.2.3b). It is worth noticing that there was at least one institution in each province carrying out the majority of procedures each year. The fluctuation in number of institutions from year over year was due to institutions with <5 cases annually. The shift in the number and location of institutions, and its impact on patient travel times can be visualized through a comparison of Figures 4.2.3d and 4.2.3e.

Except for Nova Scotia and Saskatchewan, no substantial variations in travel distances and proportion of population within one hour travel distance were observed across the provinces. In Nova Scotia, one major centre performed liver resections over the 9 year study period with small number of resections performed in other 5 centres. Therefore, the median increase in travel distance in Nova Scotia could be a result of random fluctuations in the location of patients within the province. Similar reasoning appears to apply in the context of Saskatchewan, with a substantial reduction in the median travel distance over the two time periods (114 kilometers). In spite of reductions in the number of facilities from 5 (average 2004-06) to 2 in 2010-12, the proportion of patients within one hour travel distance increased from 31% to 50% in Saskatchewan. The potential for bias in provinces with a small patient population should be kept in mind while interpreting these results. Ontario saw the biggest shift in number of institutions over time-the systematic shift could be seen in data with a sudden drop in volume in one institution in a given year followed by a sudden jump in volume in another. These findings, paired with the fact that median travel distance increased (3 kilometers) and the proportion of patients within one

hour travel time decreased (5%) may hint towards possible impacts of regionalization of liver cancer surgeries.

TABLE 4.2.3B: CHANGE IN MEDIAN TRAVEL DISTANCES FROM 2004-06 TO 2010-12

	2004-06		2010-12		Change from 2010-12 to 2004-06
Province	*Median Travel Distance in kilometers [IQR]*	*% in 1 hour travel time*	*Median Travel Distance in kilometers [IQR]*	*% in 1 hour travel time*	*Difference in Median Travel Distances (km)*
AB	19 [129]	59	18 [144]	62	-1
BC	17 [44]	64	20 [60]	62	+2
MB	13 [83]	62	13 [85]	64	0
NB	29 [110]	54	33 [124]	55	+5
NL	113 [547]	35	95 [286]	40	-18
NS	101 [229]	41	193 [280]	31	+92
ON	28 [56]	62	31 [72]	57	+3
SK	186[247]	31	72 [216]	50	-114

Resection Rate

Similar to the trends seen in pancreatic cancer resections, an overall increase in age-adjusted resection rates took place across all provinces from 2004-06 to 2010-12 (Figure 4.2.3f). Alberta had the highest (14 per 100,000) while New Brunswick had the lowest (6.9 per 100,000) resection rates in last 3 years (2010-2012). The highest improvement in resection rates for pancreatic cancers was observed in Manitoba, increasing from 5.3 to 12 resections per 100,000 populations. A comparison with Figure 4.2.3g points towards a general trend that the provinces with highest resection rates had among the lowest in-hospital mortality rates.

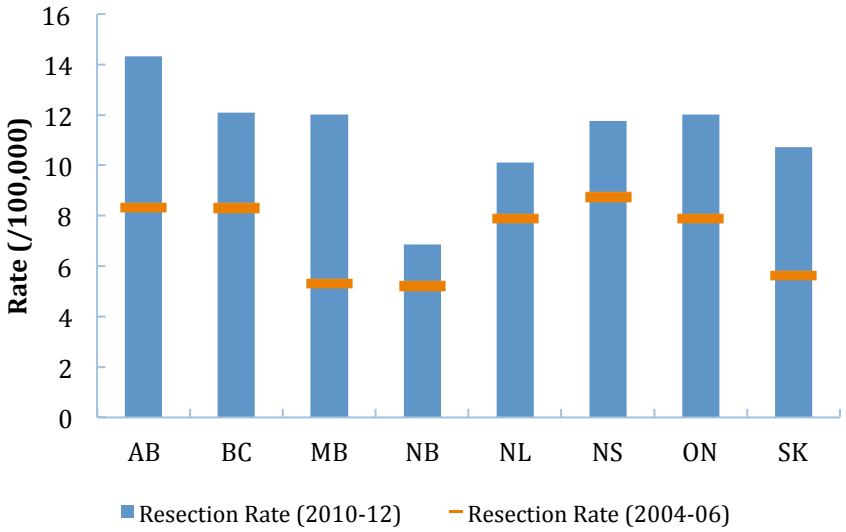


Figure 4.2.3f: Age-standardized resection rates per 100,000 populations for liver cancer surgeries

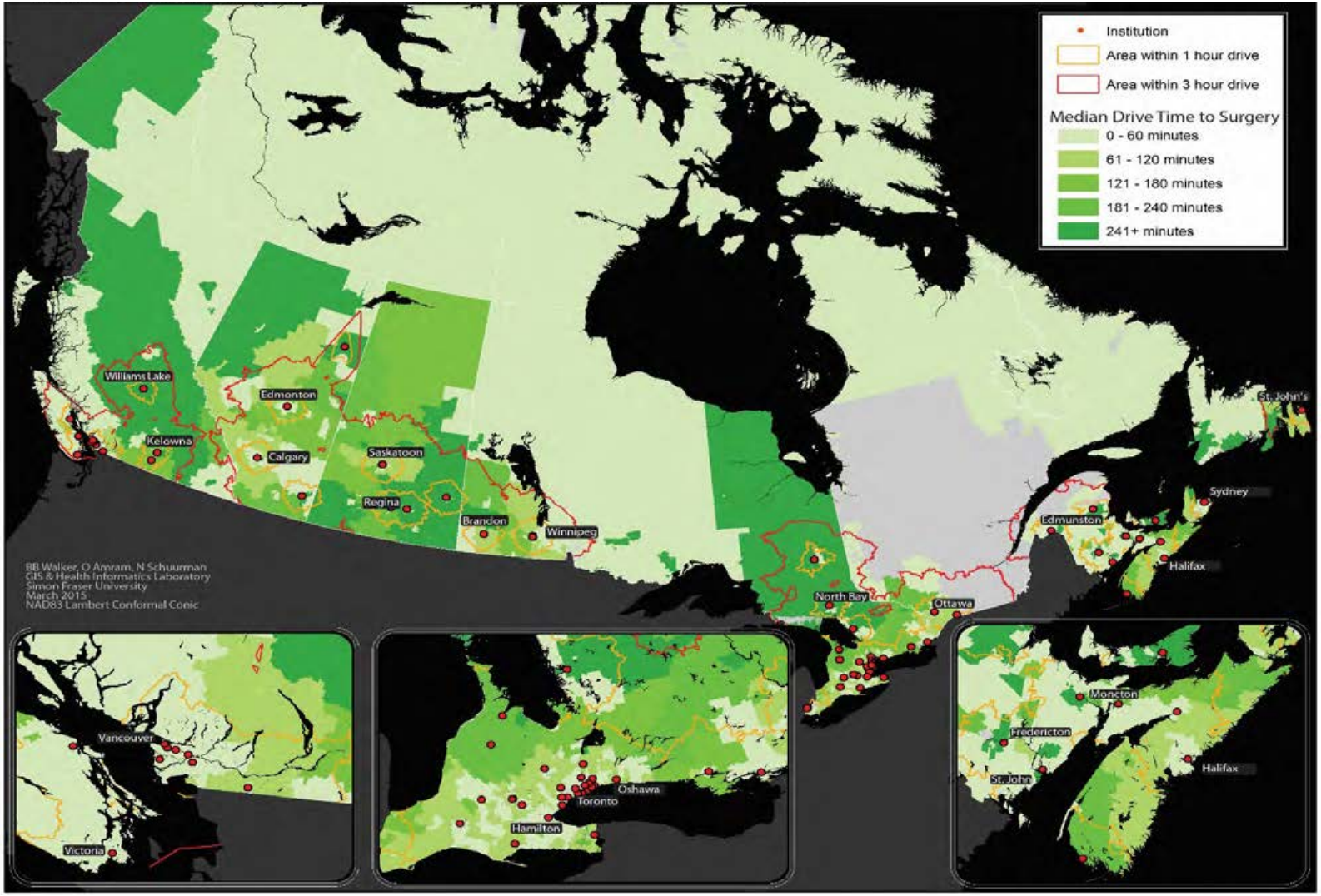


Figure 4.2.3d: Patient travel times and pan-Canadian distribution of hospitals performing liver cancer surgeries, 2004-06

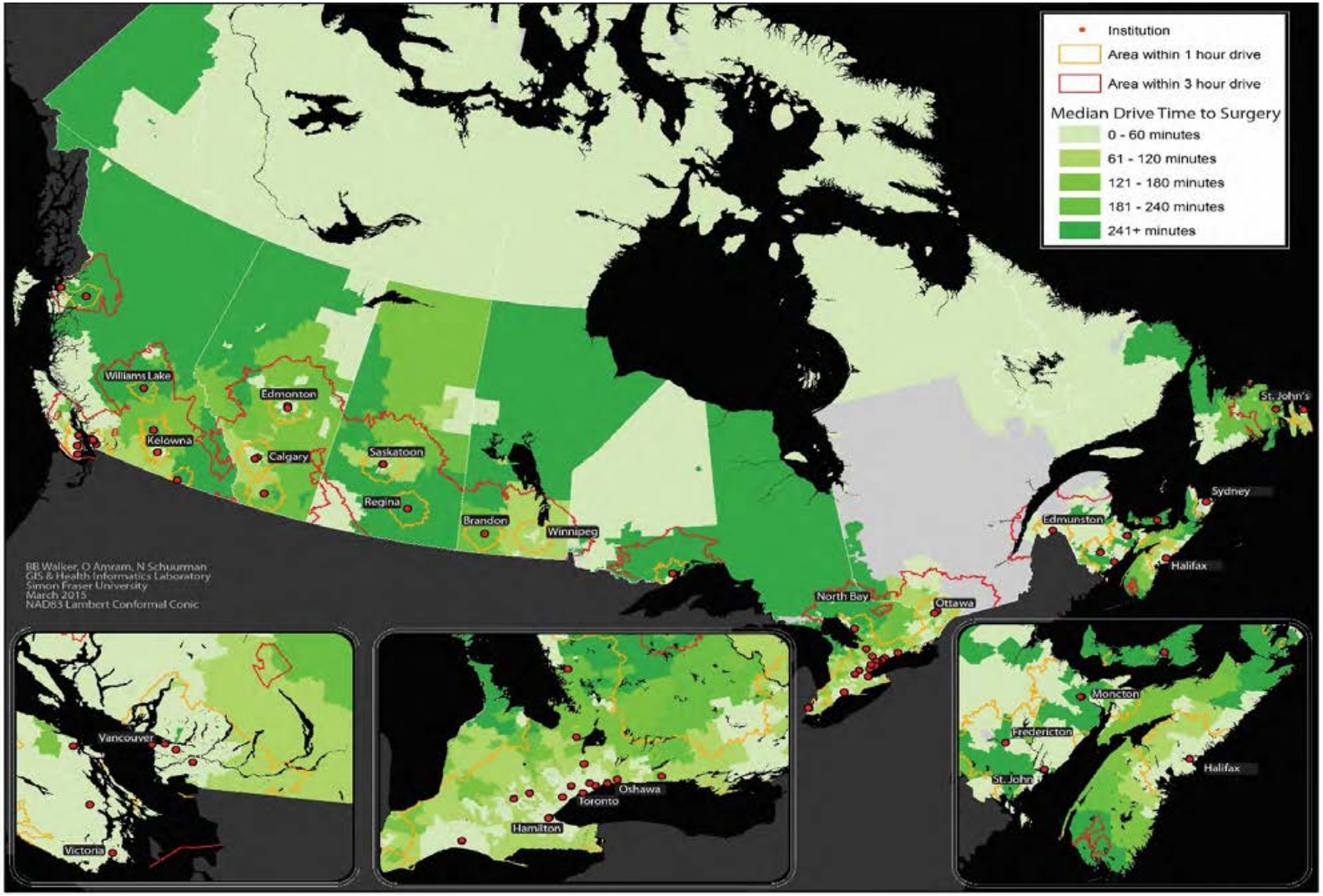


Figure 4.2.3e: Patient travel times and pan-Canadian distribution of hospitals performing liver cancer surgeries, 2010-12

In-Hospital Mortality

The overall in-hospital mortality rate for liver resections over 9-year period was 3%, declining from 3.9% in 2004 to 2.6% in 2012 (Figure 4.2.3g). The adjusted mortality rates were higher than the national average for New Brunswick, Newfoundland and Saskatchewan, however, the small number of cases could explain this large variation, as demonstrated by the error bars in Figure 4.2.3h.

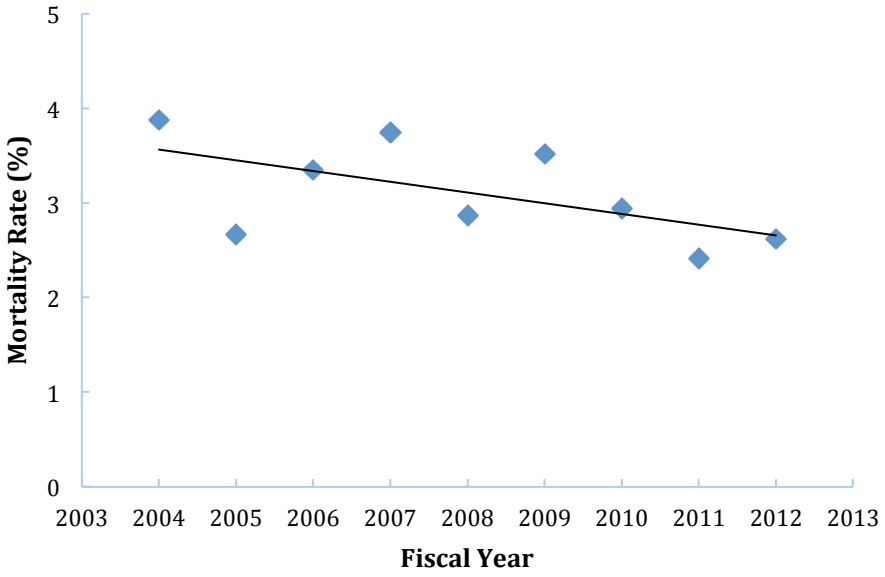


Figure 4.2.3g: Annual age-adjusted mortality rates for liver cancer surgeries (2004-12)

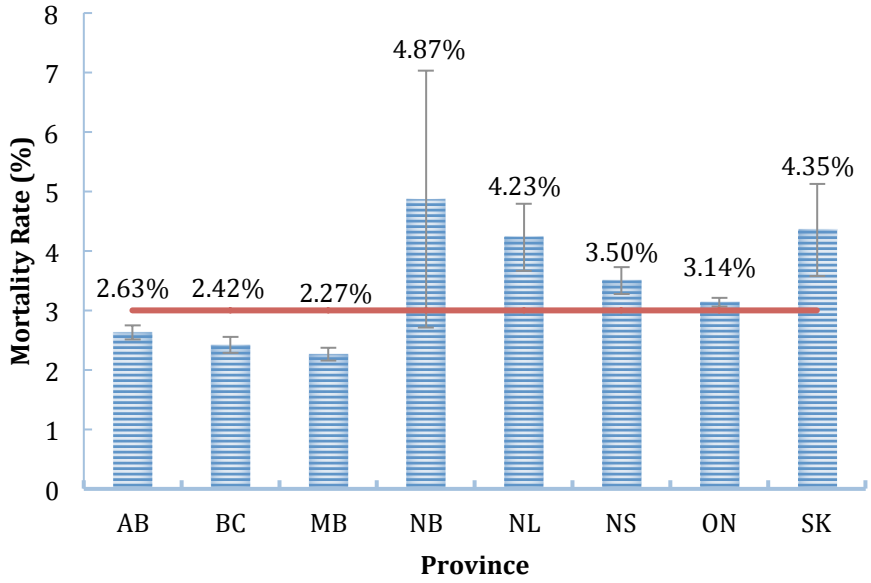


Figure 4.2.3h: Age-adjusted mortality rates for liver cancer surgeries (2004-12)

In multivariate analysis, age, co-morbidities, male patients, and open procedures were significantly associated with a greater risk of in-hospital mortality, whereas resections for secondary liver tumours carried a lower mortality risk. Non-significant differences in mortality rates between Ontario and rest of Canada were observed. The associated mortality risk for liver resections also significantly reduced over time. Figure 4.2.3i shows a trend towards lower mortality rates with increasing annual hospital volume. These differences in mortality rates with increasing hospital volume were non-significant after adjusting for random hospital or provincial differences. Surgeon volume, however, did predict a lower mortality risk in adjusted models (Appendix 4).

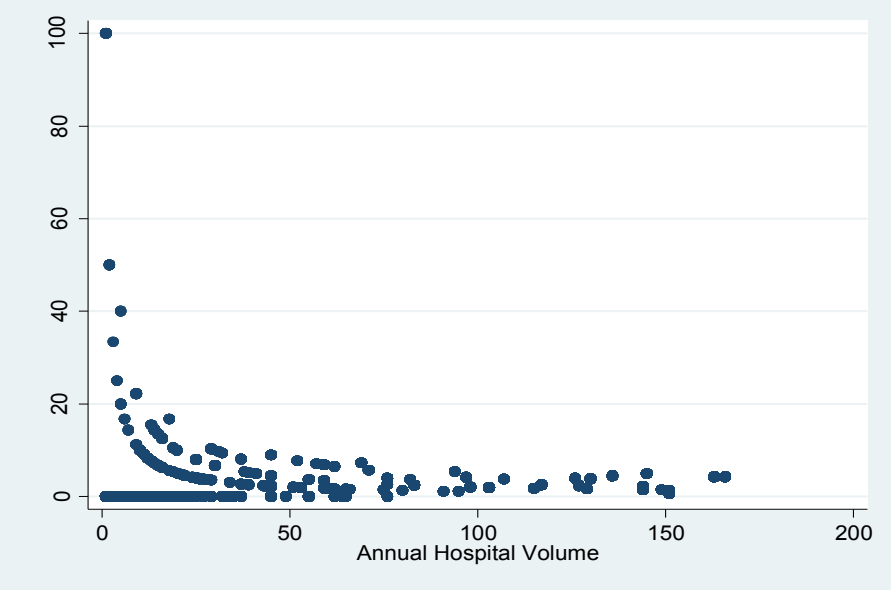


Figure 4.2.3i: Annual hospital volume and mortality rate (%) for liver cancer surgeries (2004-12)

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, theoretically a total of 15 additional lives could have been saved after liver cancer surgeries in Canada (2004-12).***

Length of Stay

The overall median length of stay for liver resections was 7 days [IQR=5], with a median reduction of one day from 2004 to 2012 (Table 4.2.3b). Saskatchewan had the highest median length of stay for liver resections (Table 4.2.3c). As observed for pancreatic cancer resections, minimally invasive procedures require shorter hospitalization as compared to open procedures (Figure 4.2.3j (a)). However, the predicted discharge rate increased with increasing institutional

TABLE 4.2.3C: MEDIAN LENGTH OF STAY

Province	Length of Stay (Median [IQR])
AB	8 [5]
BC	7 [5]
MB	7 [4]
NB	8 [4.5]
NL	7 [4]
NS	7 [4]
ON	7 [4]
SK	9 [7]

volume for both the procedures.

In survival analysis, a significantly longer length of stay was associated with patient age, co-morbidities, and open procedures. The number of expected hospital days was predicted to have declined over the years. Ontario had a lower risk of prolonged length of stay, as did resections for secondary tumours. As opposed to the trend seen in other cancer surgeries, surgeon volume predicted shorter hospital stay, while hospital volume was not a significant predictor of length of hospital stay. See Appendix 5 for complete survival analysis.

TABLE 4.2.3B: MEDIAN LENGTH OF STAY IN CANADA, BY YEAR

	Fiscal Year								
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Median Length of Stay [IQR]	8 [6]	8 [5]	7 [5]	8 [5]	7 [4]	7 [4]	7 [4]	7 [5]	7 [6]

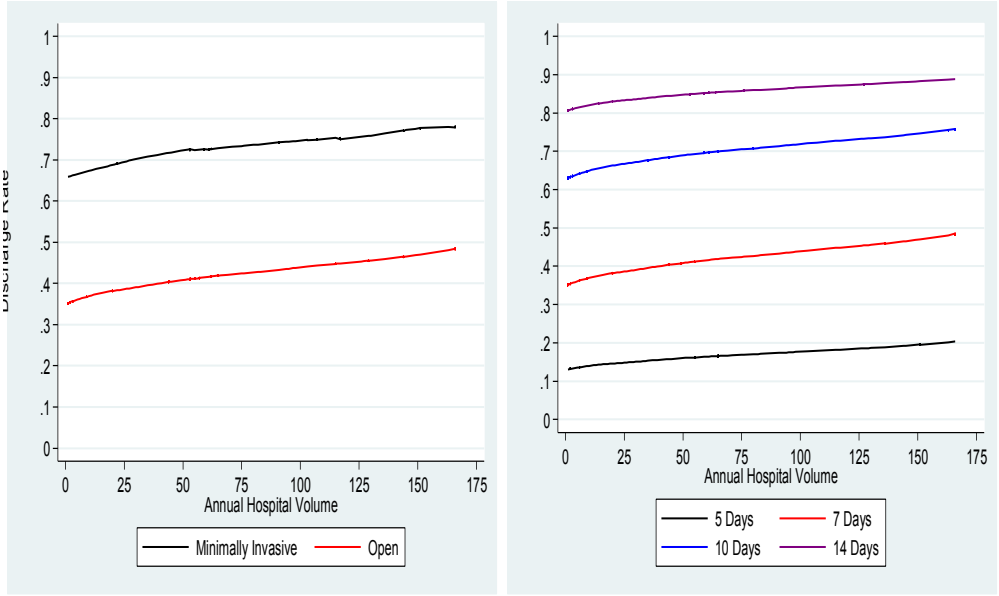


Figure 4.2.3j: Predicted discharge rate after liver cancer surgeries a. At Median 7 Days, b. Open liver resections (2004-12)

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, a total of 308 hospital days could potentially have been saved annually across Canada after liver cancer surgeries.***

4.2.4 LUNG CANCER SURGERY

Lung cancer surgical procedures had the highest volume of cases over the 9-year study period in Canada. In total, 30,284 relevant procedures were performed in 76 institutions. The mean age of patients was 66.7 (SD=10) years, with 52% of patients being male. The median hospital volume was 129 surgeries per year [IQR=108], whereas the median surgeon volume was 40 [IQR=27]. The annual number of lung surgeries increased 29%, from 2942 in 2004 to 3795 in 2012. An increase in number of procedures was observed in all provinces, except Nova Scotia (Table 4.2.4a, Figure 4.2.4a). Over the same time period, the number of institutions performing lung surgeries decreased from 65 to 43 (Figure 4.2.4b). The three known provinces that have taken steps to actively regionalize lung cancer surgical care are Ontario, British Columbia, and Manitoba. Subsequent reductions in number of institutions performing these resections were observed in Ontario (37 to 24), and British Columbia (8 to 4). Although a shift from 3 to 2 institutions was observed in Manitoba, there was one centre carrying out 94% of lung cancer surgeries in 2012.

Lung resections were classified into five categories based on surgical complexities associated with each approach. In order of increasing complexity, these include: 1) Video Assisted Thoracoscopic Surgery minimally invasive (VATS) sub-lobar resection, 2) Open thoracotomy sub-lobar resection, 3) VATS lobectomy, 4) Open lobectomy, and 5) Pneumonectomy. Open lobectomy was the most performed procedure (35%), consisting of the removal of a full lobe of the lung followed by open sub-lobar resection (28%), which is the removal of only a portion of a lobe. Lung cancer surgeries are normally performed by Thoracic surgeons, although 25% of lung surgeries in Canada were performed by general surgeons. A higher proportion of surgeries completed by general surgeons is reported in New Brunswick 52%, Ontario (32%) and Saskatchewan (47%). It should be noted that coding practices for surgeon specialty are subject to debate, as described in Appendix 3.

TABLE 4.2.4A: TOTAL NUMBER OF LUNG CANCER SURGERIES IN CANADA (2004-12)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
AB	241	285	291	330	340	348	326	382	403	2946
BC	464	482	484	506	523	583	504	531	614	4691
MB	205	224	188	212	214	243	228	246	226	1986
NB	122	147	154	139	189	166	186	202	213	1518
NL	44	49	39	35	49	61	65	64	49	455
NS	183	181	207	184	197	205	206	195	176	1734
ON	1550	1680	1737	1837	1689	1781	1694	1800	1964	15732
PEI	*	*	*	*	*	*	*	*	*	*
SK	130	150	139	140	124	129	134	122	150	1218
Canada	**2942**	**3199**	**3239**	**3383**	**3325**	**3516**	**3343**	**3542**	**3795**	**30284**

**Number suppressed if number of surgeries <5*

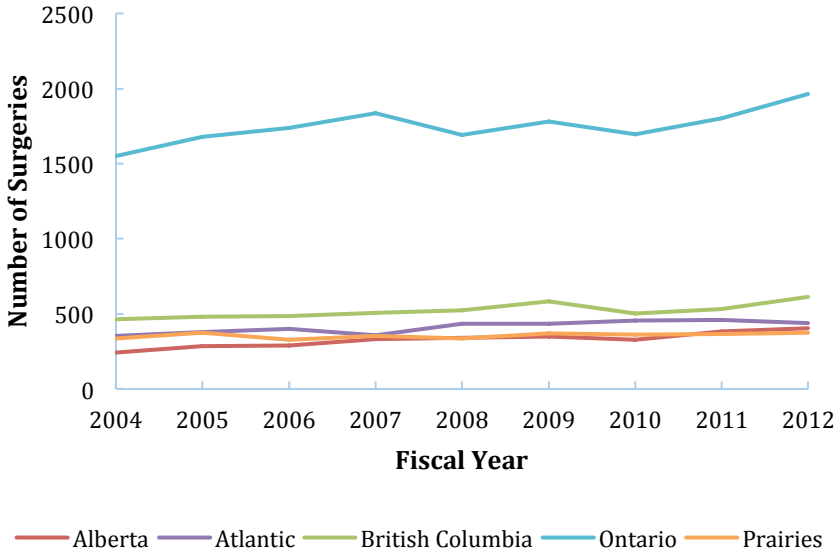


Figure 4.2.4a: Number of lung cancer surgeries, by province (2004-12)

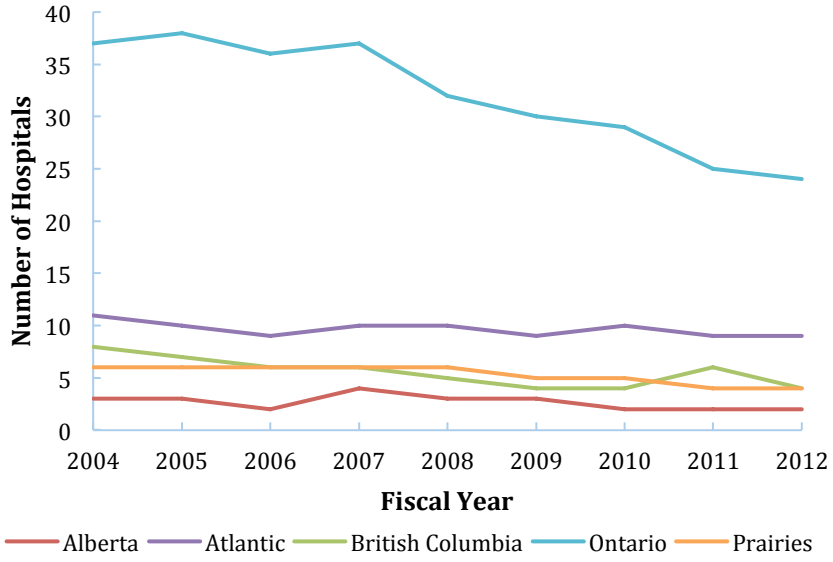


Figure 4.2.4b: Number of institutions performing lung cancer surgeries, by province (2004-12)

Travel Distance

Table 4.2.4b presents a comparison of changes in median travel distances over time across the provinces for lung cancer surgery. An interesting finding is that the implementation of standards for regionalization of thoracic cancer surgeries in Ontario and accounts of such measures in British Columbia and Manitoba had mixed impacts on travel times. An increase in median travel time and the respective proportion of patients within 1 hour driving

distance to the surgical centre was observed in Ontario with a move towards regionalization. However, the median travel time for lung resections was reduced in British Columbia and Manitoba between the earliest and latest 3 year intervals. These findings are astounding given the clear evidence of a shift to fewer facilities. In British Columbia, there were 8 facilities performing lung surgeries in 2004, but there were only 4 left in 2012. In spite of occasional surgeries in other centres, the data shows consistent consolidation to these 4 high volume centres. Still, the proportion of patients within 1 hour driving distance increased by 6%, thus shortening the median travel distance over time. Similarly, a shift to 2 facilities (from 3) was evident in Manitoba around 2009-10 without any changes in proportion of population within 1 hour commute. In concordance with the findings for British Columbia, the median travel time decreased by 5 kilometers over time. While it could not be confirmed, Saskatchewan did not have a formal process for regionalization of cancer surgical care, yet a gradual reduction from 3 to 2 facilities is obvious in the data. The median travel time also decreased with an increase in the proportion of patients having driven less than an hour for surgery. A similar move from 4 facilities to 3 in Alberta resulted in minuscule changes travel distance and time. The geographic maps presented in Figures 4.2.4c and 4.2.4d can further assist in visualization of distribution of facilities across the provinces and any changes in these distributions over time.

TABLE 4.2.4B: CHANGE IN MEDIAN TRAVEL DISTANCES FROM 2004-06 TO 2010-12

Province	**2004-06**		**2010-12**		**Change from 2010-12 to 2004-06**
	Median Travel Distance in kilometers [IQR]	*% in 1 hour travel time*	*Median Travel Distance in kilometers [IQR]*	*% in 1 hour travel time*	*Difference in Median Travel Distances (kilometers)*
AB	17 [128]	62	18 [118]	62	+1
BC	32 [102]	52	25 [93]	58	-7
MB	18 [120]	63	13 [94]	63	-5
NB	37 [92]	50	48 [115]	45	+11
NL	95 [324]	40	292 [539]	30	+198
NS	81 [150]	44	71 [148]	45	-10
ON	18 [52]	71	26 [69]	63	+8
SK	118 [197]	38	73 [186]	46	-45

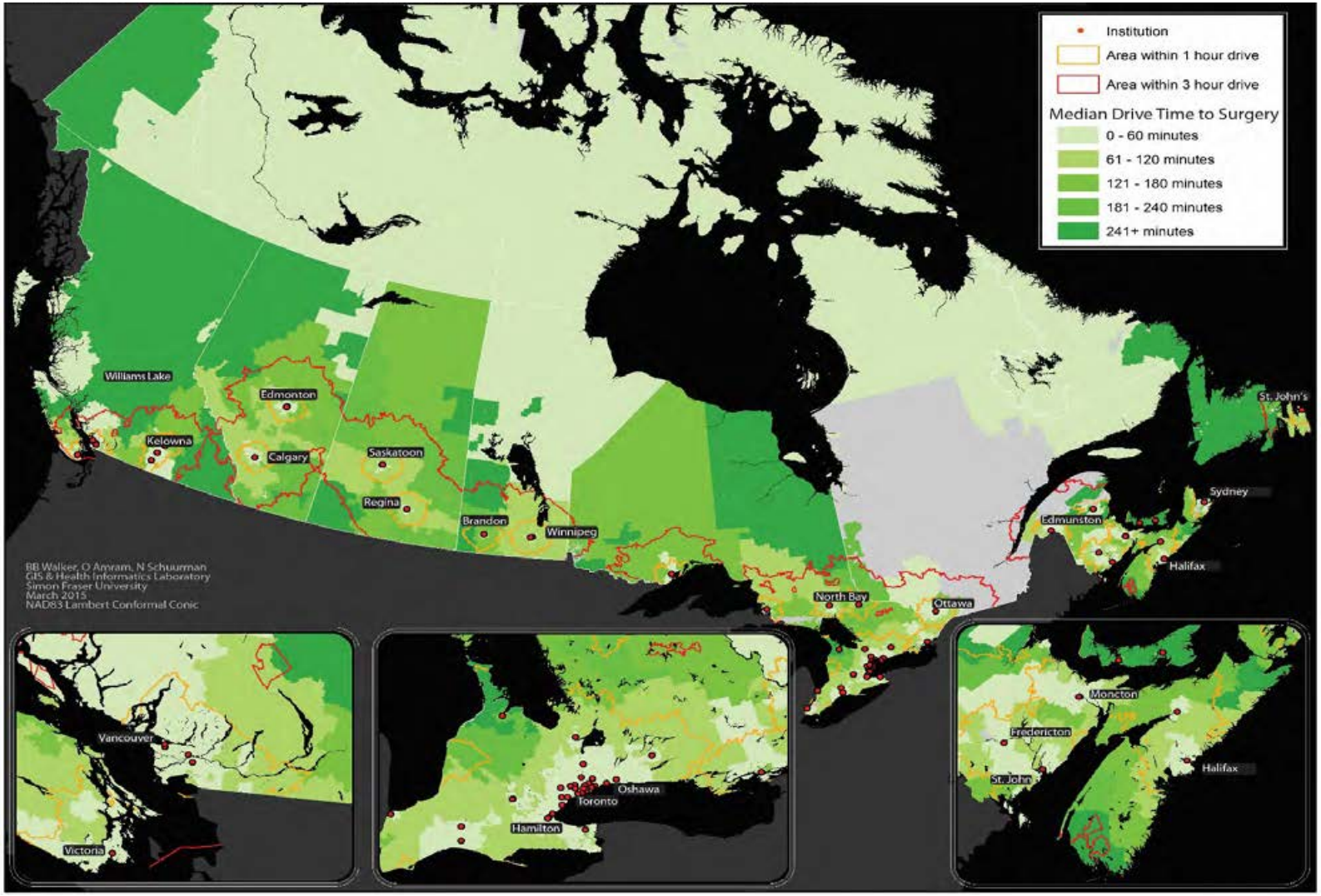


Figure 4.2.4c: Patient travel times and pan-Canadian distribution of hospitals performing lung cancer surgeries, 2004-06

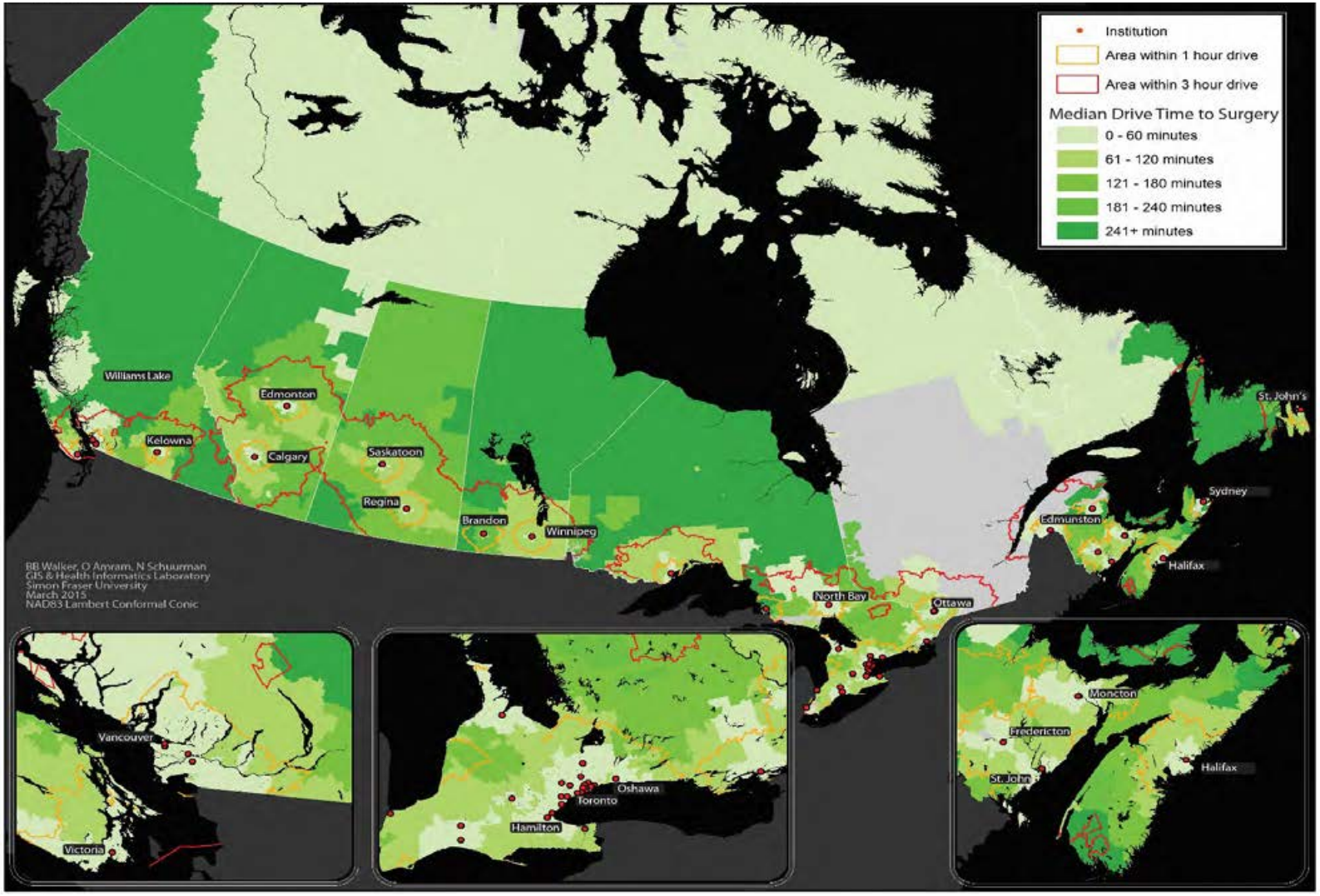


Figure 4.2.4d: Patient travel times and pan-Canadian distribution of hospitals performing lung cancer surgeries, 2010-12

Resection Rate

Figure 4.2.4e shows that New Brunswick had the highest resection rate for lung cancer surgeries, increasing from 43 to 58 resections per capita over the two time periods. Manitoba and Nova Scotia did not show such a sharp rise in resection rates over the intervals under study, with rates that were already markedly higher than the other provinces (51 and 48 resections per capita, respectively) in 2010-2012. The rates increased across all provinces from 2004-06 to 2010-12, except Saskatchewan. Between Newfoundland, with the lowest resection rate for lung surgeries, and New Brunswick with the highest rate, there was a difference of 30 resections per capita. These findings combined with the relative differences between the incidence and resection rates possibly indicate disparities in care delivery based on geographic location.

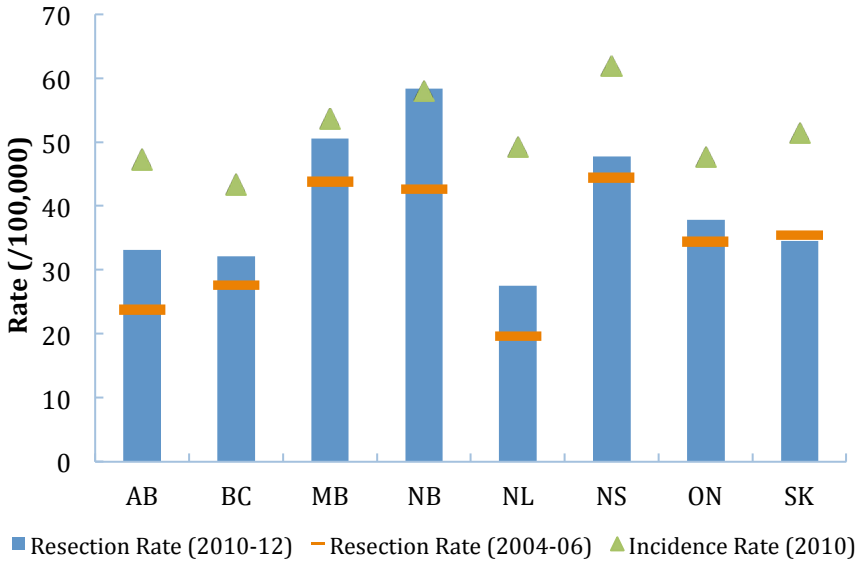


Figure 4.2.4e: Age-standardized resection rates per 100,000 populations for lung cancer surgeries

In-Hospital Mortality

The overall lung cancer surgery in-hospital mortality rate for the 9-year period was 2.3%, with a large (50%) reduction in mortality occurring between 2004 (3.2%) and 2012 (1.6%) (Figure 4.2.4f). Differences between provinces were also apparent. New Brunswick had a mortality rate 1.4% higher than the 9-year national average and Ontario, Saskatchewan, and Nova Scotia had marginally higher age-adjusted mortality rates. A reduction in mortality rates over time within each province was seen as well (Figure 4.2.4g). For instance, Ontario had a crude mortality rate of 3.1% in the first 3 years (2004-06) which reduced to 1.8% in last 3 years (2010-12). Similarly, a reduction from 2.38% to 1.09% in British Columbia, and 2.08% to 1.6% in Alberta was recorded over the same period. Such differences were difficult to present for provinces with smaller caseloads. The relatively

recent large scale adoption of minimally invasive techniques, a paradigm shift that is unique to lung surgery, may have also influenced the rate of mortality.

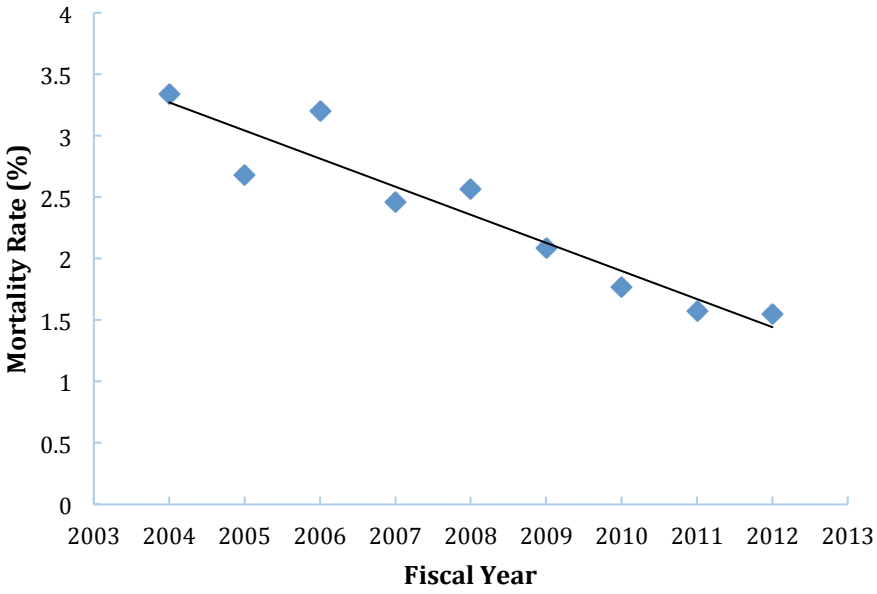


Figure 4.2.4f: Annual age-adjusted mortality rate for lung cancer surgeries (2004-12)

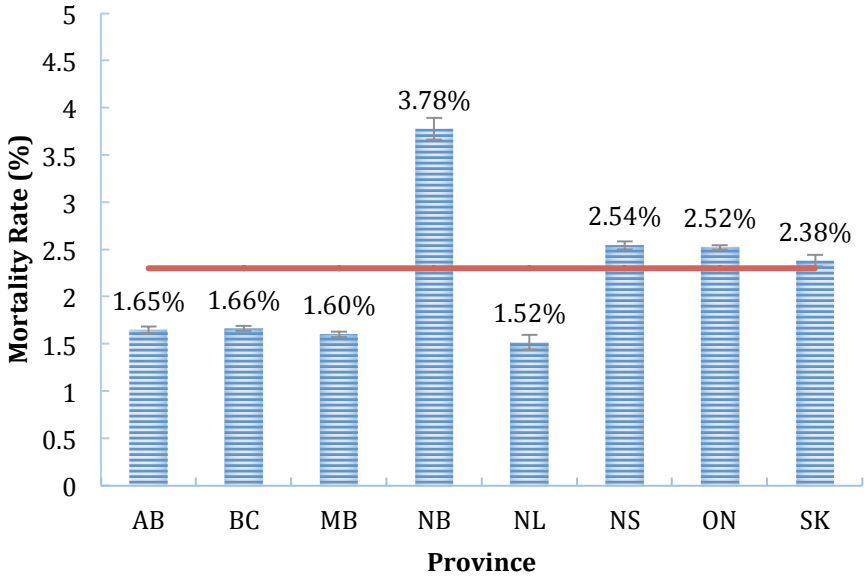


Figure 4.2.4g: Age-adjusted mortality rates for lung cancer surgeries (2004-12)

In the multivariate regression model, higher age, co-morbidity score, and males had a higher risk of in-hospital mortality after resection for lung cancer. Open procedures had twice the risk of mortality, whereas pneumonectomy had six times the risk of mortality

compared to minimally invasive procedures. The risk of mortality also appeared to have significantly reduced over time.

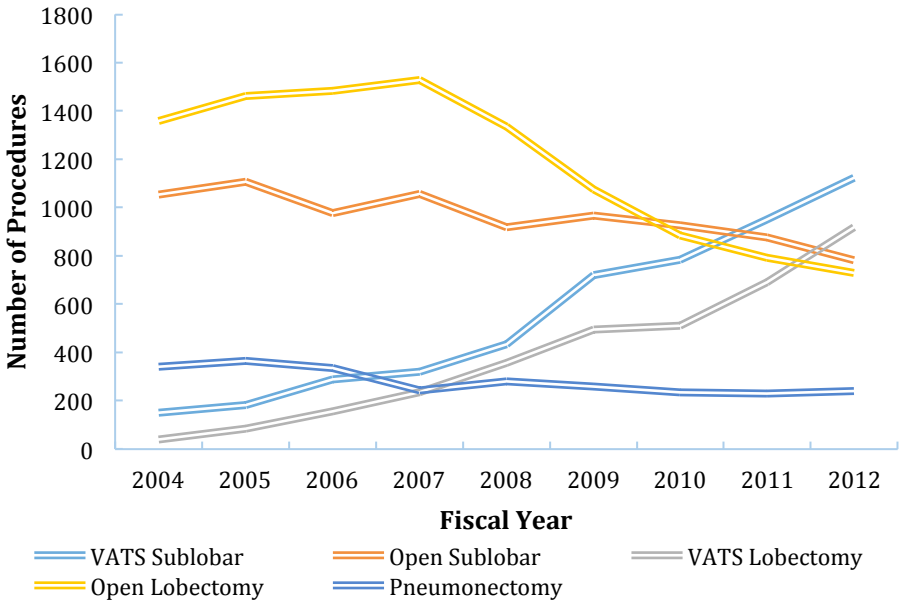


Figure 4.2.4h: Shift in lung cancer procedures in Canada (2004-12)

One of the possible reasons for this reduction in mortality rates after lung cancer resections is a shift towards minimally invasive procedures over time, which is associated with lower mortality rates (Figure 4.2.4h).[77] Alternatively, it is also possible that lower-risk sublobar VATS resections were able to be selected rather than higher risk lobectomy and pneumonectomy procedures due to an increase in earlier detection of smaller tumours during this time period.

In univariate analysis, both hospital and surgeon volumes were significantly associated with the mortality rate. Similarly, thoracic surgeons had a lower mortality rate (2%) on average than the general surgeons. Figure 4.2.4i demonstrates the crude mortality rate reduction for annual hospital volume. After controlling for random hospital related factors or provincial variations, hospital volume was significantly associated with a reduced risk of in-hospital mortality (Appendix 4). Surgeon volume and specialty significantly predicted the risk of mortality in the model but the effect disappeared with the inclusion of hospital volume. Furthermore, the random effects of hospital were also significant implying that factors other than volume and specialty also predict mortality.

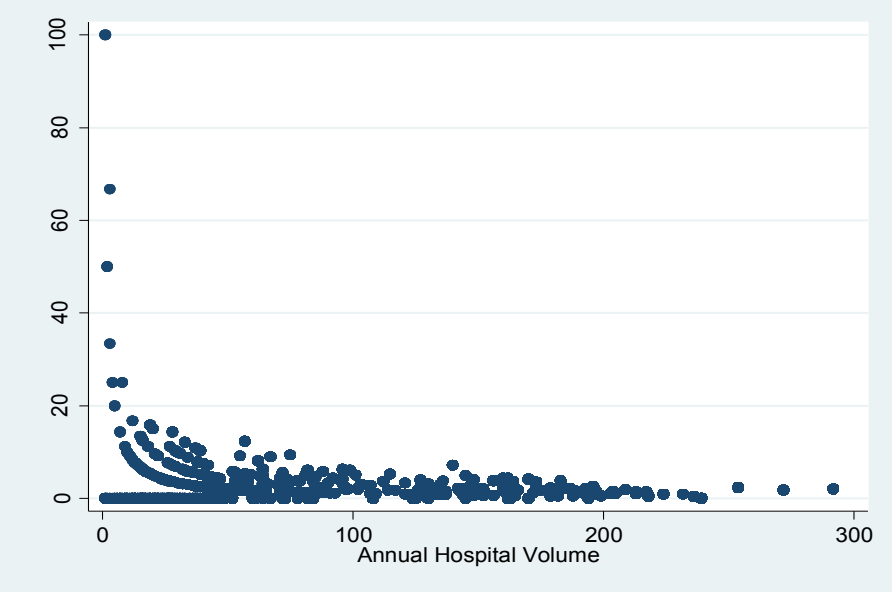


Figure 4.2.4i: Annual hospital volume and mortality rate (%) for lung cancer surgeries (2004-12)

- ***According to multivariate analysis, an annual increase of 10 cases in a given hospital predicted a 3% reduction in risk of in-hospital mortality, after controlling for the influence of covariates and random clustering effects of individual hospitals.***

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, theoretically a total of 209 additional lives could have been saved after lung cancer surgeries in Canada (2004-12).***

Length of Stay

The median length of stay of 6 days [IQR=5] for lung cancer surgeries was the lowest amongst the five cancer types. Over the course of the nine-year study period, the median length of stay decreased from 7 days to 5 days across Canada (Table 4.2.4b). There was a median difference of three days between Manitoba, with shortest hospital stay (5 days), and Newfoundland and New Brunswick with the longest hospital stay (8 days) (Table 4.2.4c). Strong linear associations between higher annual facility volume and higher rates of discharge 6 days after surgery are evident in Figure 4.2.4j. VATS procedures are least

TABLE 4.2.4C: MEDIAN LENGTH OF STAY

Province	Median Length of Stay [IQR]
AB	6 [5]
BC	7 [4]
MB	5 [3]
NB	8 [5]
NL	8 [4]
NS	6 [3]
ON	6 [4]
SK	7 [4]

invasive, hence, had a higher discharge rate at any given case volume relative to the other two procedures. Pneumonectomy and open procedures showed the greatest variability in length of stay at a volume of at least 250 resections a year (Figure 4.2.4k).

TABLE 4.2.4B: LENGTH OF STAY IN CANADA AFTER LUNG CANCER SURGERY, BY YEAR

	Fiscal Year								
	2004	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**	**2012**
Median Length of Stay [IQR]	7 [4]	7 [4]	7 [5]	6 [4]	6 [4]	6 [4]	6 [4]	5 [4]	5 [4]

After controlling for hospital clustering effect and other factors in the model, higher age, co-morbidity score, and male patients were associated with higher risk of longer length of stay (Appendix 5). In comparison to the relatively lower risk VATS sub-lobar resection, all other procedures required relatively longer hospitalization. Yearly reductions in number of hospital days were significant. Surgeries in Ontario predicted a significantly shorter hospital stay in comparison with those resections performed elsewhere in Canada. Both the hospital and surgeon volume significantly predicted shorter length of stay with increasing volume. Interestingly, surgeries conducted by general surgeons predicted a shorter length of stay for the patients, but the differences were not significant.

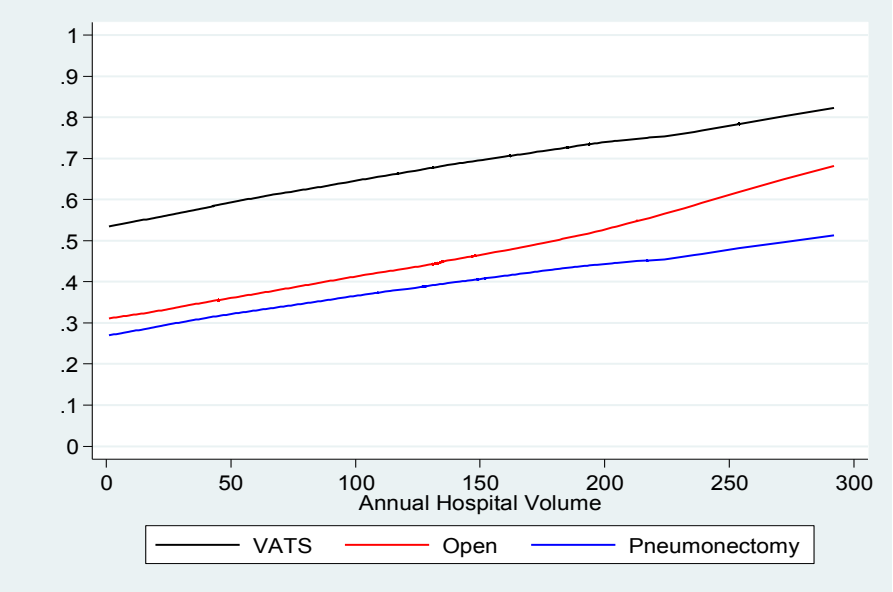


Figure 4.2.4j: Predicted discharge rate 6 days after lung cancer procedures (2004-12)

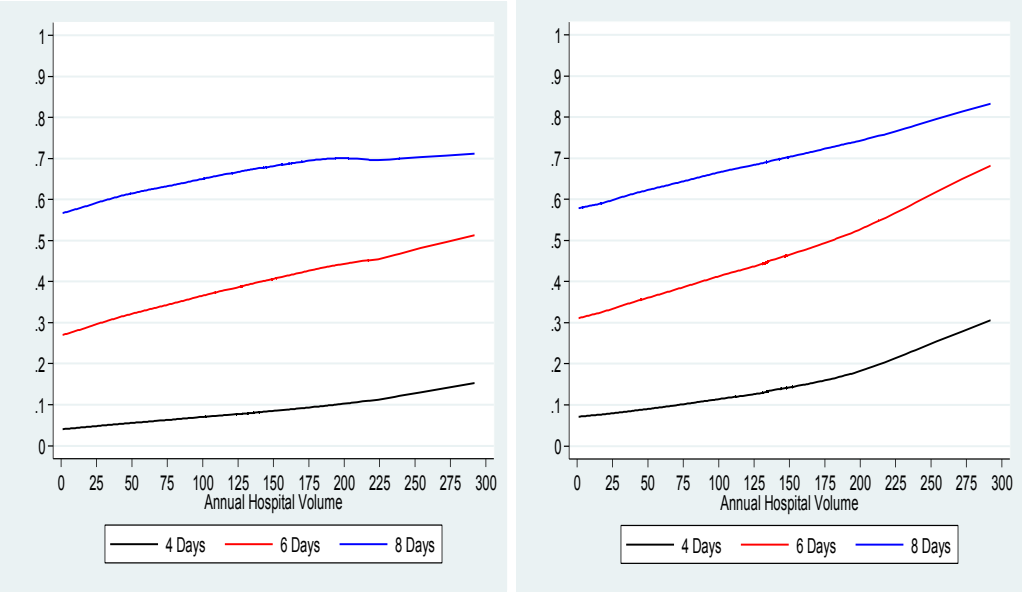


Figure 4.2.4k: Predicted discharge rate after a. Pneumonectomy, b. Open Sub-lobar (2004-12)

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, a total of 3335 hospital days could potentially have been saved annually across Canada for lung cancer surgeries.***

4.2.5 OVARIAN CANCER SURGERY

Ovarian cancer resections constituted the second highest case volume, with 16,949 surgeries performed in 232 institutions across Canada (excluding Quebec). The mean age of patients was 56.2 (SD=14.6) years. The median hospital volume was 68 resections per year [IQR=101], and the median surgeon volume was 16 resections per year [IQR=26]. The annual number of surgeries increased 11% from 1814 in 2004 to 2030 in 2012. A consistent increase in the annual number of procedures was observed in Ontario, Manitoba, and Nova Scotia (Table 4.5.2a; Figure 4.2.5a). Although the number of hospitals performing ovarian resections decreased from 176 to 150 (Figure 4.2.5b) over the 9-year period, this reduction appears to be a result of random year-to-year fluctuations in institutions with a low case volume (≤2 surgeries per year).

TABLE 4.2.5A: NUMBER OF OVARIAN CANCER SURGERIES, BY PROVINCE (2004-12)

	2004	2005	2006	2007	2008	2009	2010	2011	2012	Total
AB	254	233	238	241	255	209	253	238	261	2182
BC	317	360	360	331	330	329	337	356	331	3051
MB	82	90	101	93	88	98	121	113	109	895
NB	59	74	58	52	39	60	72	55	57	526
NL	38	40	39	32	38	36	41	45	53	362
NS	72	76	74	71	85	99	84	79	91	731
ON	893	888	923	887	876	916	946	957	1054	8340
PEI	13	10	*	*	*	*	10	9	*	62
SK	86	77	81	99	109	95	85	99	69	800
Canada	**1814**	**1848**	**1877**	**1808**	**1825**	**1847**	**1949**	**1951**	**2030**	**16949**

**Number suppressed if number of surgeries ≤5*

Ovarian resection types were classified into six categories by an expert Gynecological Oncologist based on the degree of surgical intensity, which stratifies the associated risks. Procedure types in order of increasing complexity are: omentectomy, minimally invasive oophorectomy/fallopian tube resection, open oophorectomy/fallopian tube resection, minimally invasive simple hysterectomy, open simple hysterectomy, and radical hysterectomy. Gynecological cancer procedures could involve any combination of either the removal of ovaries, fallopian tube(s), or uterus using a minimally invasive or open approach. Procedures were classified based on the most complex surgical intervention in cases where there was a combination of interventions. For instance, if a patient underwent omentectomy and open radical hysterectomy, the procedure was classified as open radical hysterectomy. A majority of procedures were categorized as an open simple hysterectomy (59%) and an open oophorectomy/fallopian tube resection (29%). It is not uncommon in ovarian cancer surgeries that patients undergo further debulking or another associated resection at a later point in time. The present data only provided records for one patient visit, without the possibility of accounting for multiple visits by the same patient for a follow up procedures. Therefore, any follow-up procedure(s) would be treated as a new cancer occurrence and a new surgical case.

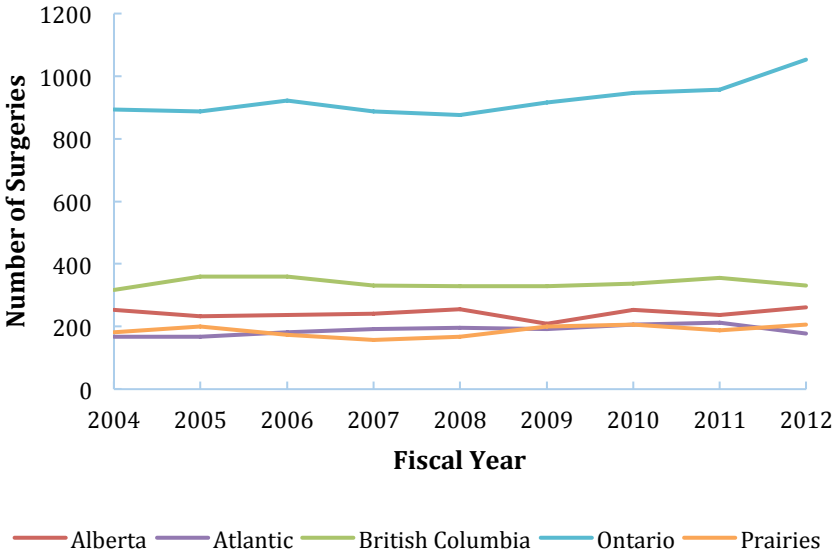


Figure 4.2.5a: Number of ovarian cancer surgeries, by province (2004-12)

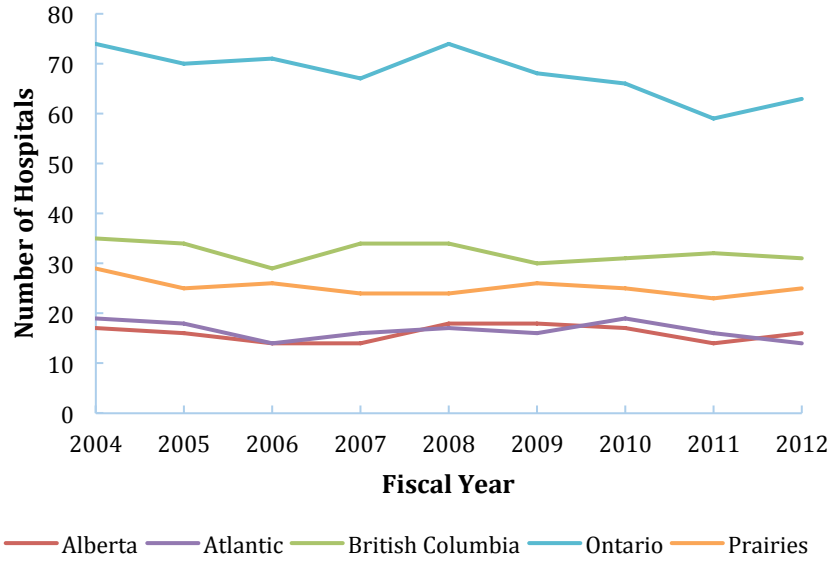


Figure 4.2.5b: Number of institutions performing ovarian cancer surgeries, by province (2004-12)

Travel Distance

Ovarian cancer procedures had the shortest median travel times in all provinces for the five high risk cancers discussed here. This trend holds true for all the provinces, across all the years (Table 4.2.5b). They appear to be least centralized, given the high number of institutions with small annual case load (≤5 resections). Overall, the number of facilities varied from year to year within the same province due to volume fluctuations among facilities providing ≤5 resections per year. For example, 102 institutions performed at least one surgery for ovarian cancer in Ontario over the 9-year period. In 2004, 74 institutions performed at least one surgery as compared to 63 in 2012. However, if only institutions with more than one surgery in a given year are counted, the reduction from 2004 to 2012 was 58 to 53 hospitals. Similar trends were observed in other provinces as well. For instance, a total of 14 hospitals performed at least one surgery over 9 years (10 in 2004 to 5 in 2012) in Manitoba. Although only 2 big institutions were carrying out the highest caseload, the fluctuation in number of facilities each year was mainly a result of institutions carrying out small (1 to 5) number of surgeries one year and nothing the next year.

The random fluctuations in hospitals performing ovarian cancer surgeries could have impacted the difference in median travel distance and proportion of individuals within an hour distance of surgical centre. Figures 4.2.5c and 4.2.5d demonstrate the distribution of institutions performing ovarian cancer surgeries across provinces and the respective changes in proportion of patients within 1-3 hours commute. As opposed to the other cancer surgeries, 2 centres in Prince Edward Island performed a small number of surgeries throughout the 9-year study period.

TABLE 4.2.5B: CHANGE IN MEDIAN TRAVEL DISTANCES FROM 2004-06 TO 2010-12

Province	**2004-06**		**2010-12**		**Change from 2010-12 to 2004-06**
	Median Travel Distance in kilometers [IQR]	*% in 1 hour travel time*	*Median Travel Distance in kilometers [IQR]*	*% in 1 hour travel time*	*Difference in Median Travel Distances (kilometers)*
AB	17 [106]	65	17 [96]	65	0
BC	12 [34]	72	17 [47]	68	+5
MB	13 [96]	65	12 [53]	70	-1
NB	29 [79]	56	58 [177]	41	+29
NL	23 [136]	56	25 [149]	56	+2
NS	70 [186]	45	51 [187]	48	-19
ON	19 [47]	71	25 [54]	67	+6
SK	9 [122]	58	50 [161]	52	+42

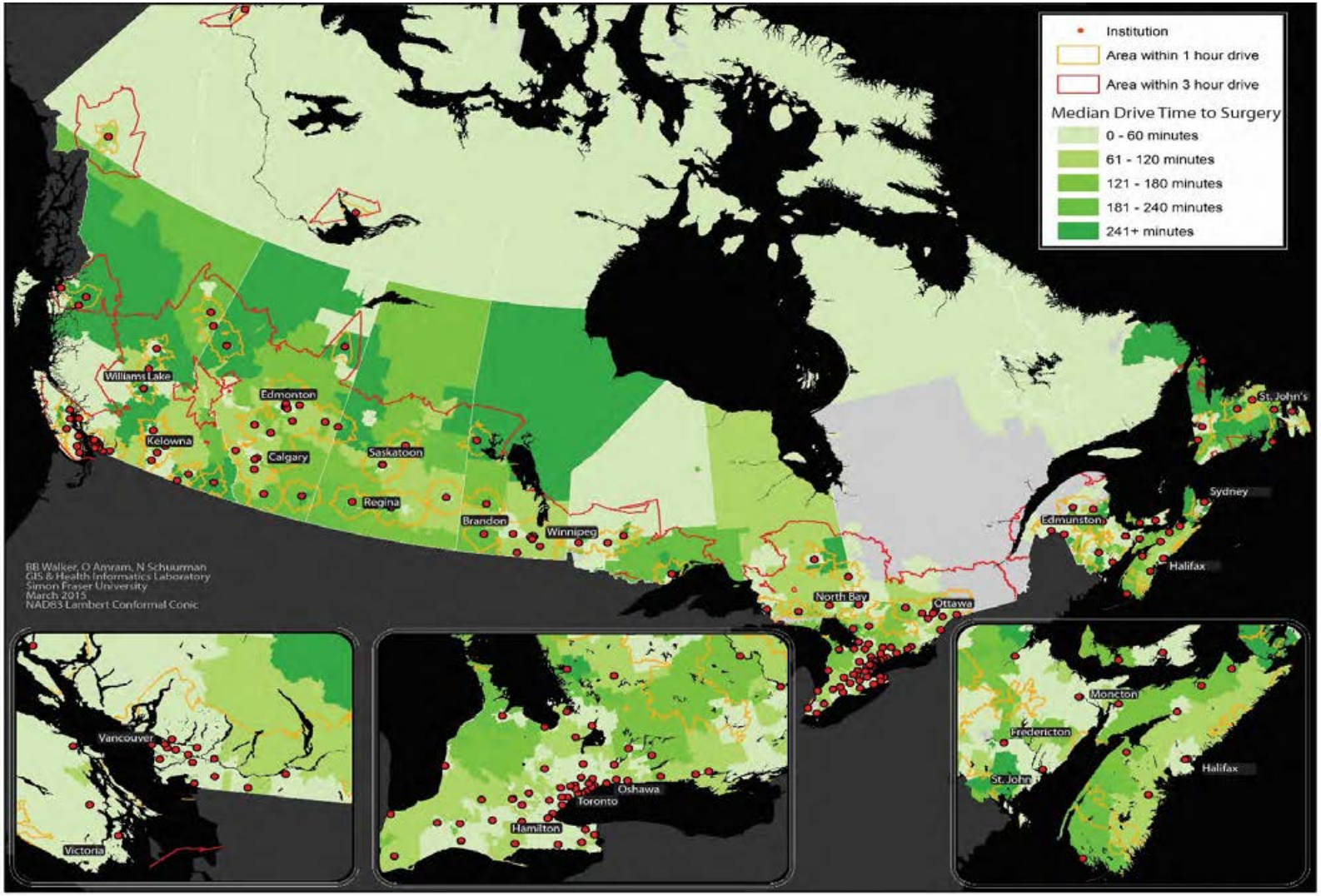


Figure 4.2.5c: Patient travel times and pan-Canadian distribution of hospitals performing ovarian cancer surgeries, 2004-06

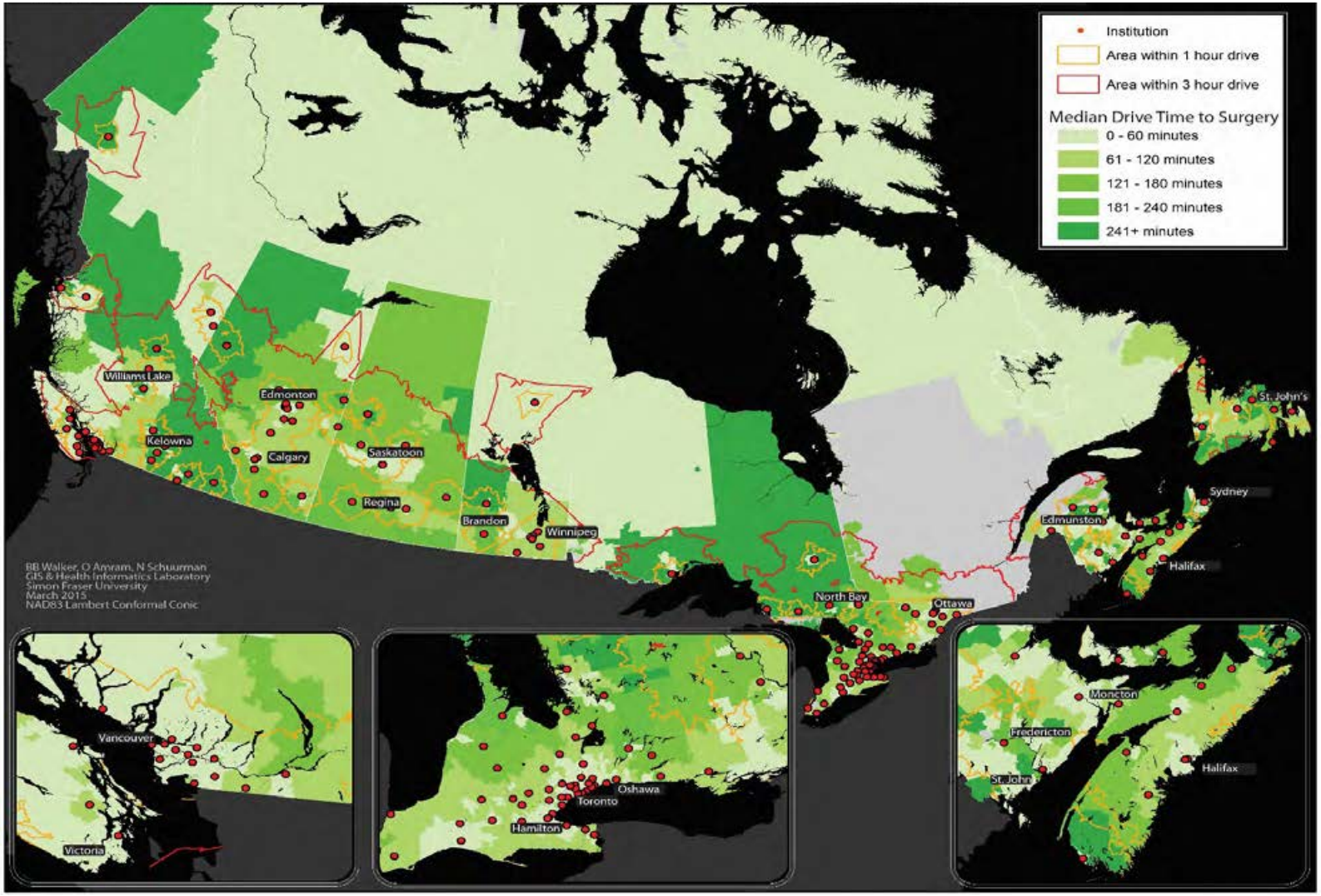


Figure 4.2.5d: Patient travel times and pan-Canadian distribution of hospitals performing ovarian cancer surgeries, 2010-12

Resection Rate

Ovarian cancer surgeries had the lowest inter-provincial differences in resection rates amongst all cancers of interest. Apart from Manitoba with an increase of 5 resections per capita, the remaining provinces had minimal changes in resection rates over the two time period. In 2010-12, there was a difference of over 5 resections per 100,000 between the province with highest number of ovarian cancer surgeries per capita (Manitoba) to provinces with the lowest (Alberta, Nova Scotia) (Figure 4.2.5e). The relatively small inter-provincial differences in resection rates do not correlate well with the large differences in in-hospital mortalities in Figure 4.2.5g.

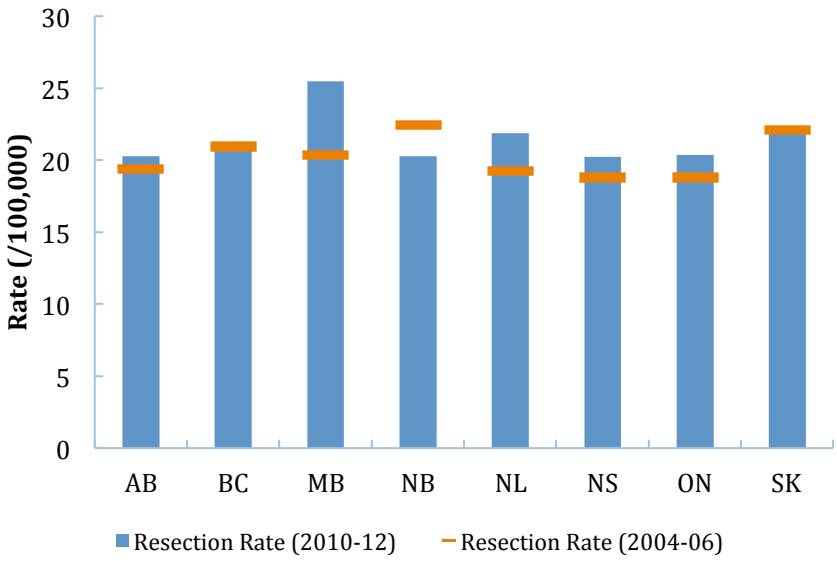


Figure 4.2.5e: Age-standardized resection rates per 100,000 populations for ovarian cancer surgeries

In-Hospital Mortality

Ovarian cancers had the lowest mortality rate amongst the five cancers under investigation. The overall in-hospital mortality rate for the 9-year study period was 0.9%, declining from 1.3% in 2004 to 0.69% in 2012 (Figure 4.2.5f), with variations is mortality rates evident over the 9-year period. Provincially, there was apparent variation. Prince Edward Island had the highest in-hospital mortality of 2.84% (SD=1.3) although it only performed 60 resections in 9 years and Newfoundland, Nova Scotia, and New Brunswick had age-adjusted mortality rates that were considerably higher than the national 9-year average of 0.9% (Figure 4.2.4g).

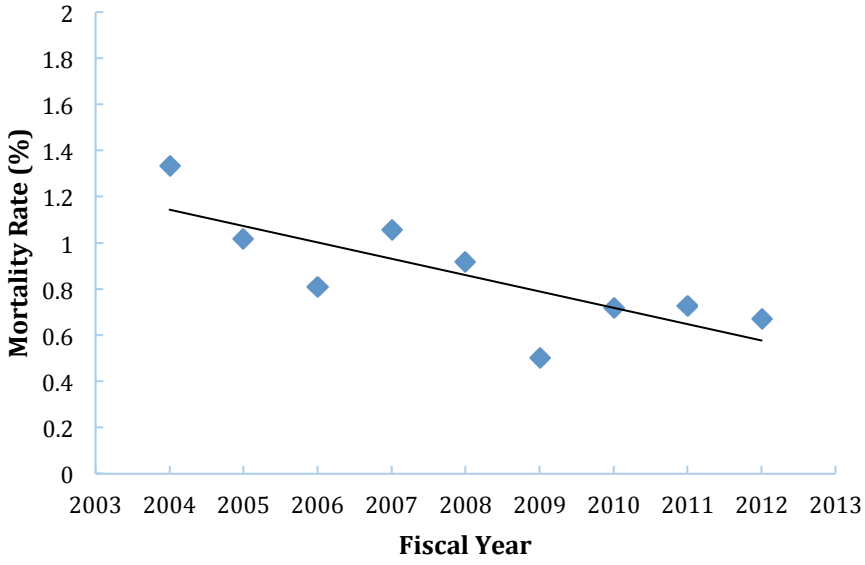


Figure 4.2.5f: Annual age-adjusted mortality rates for ovarian cancer surgeries (2004-12)

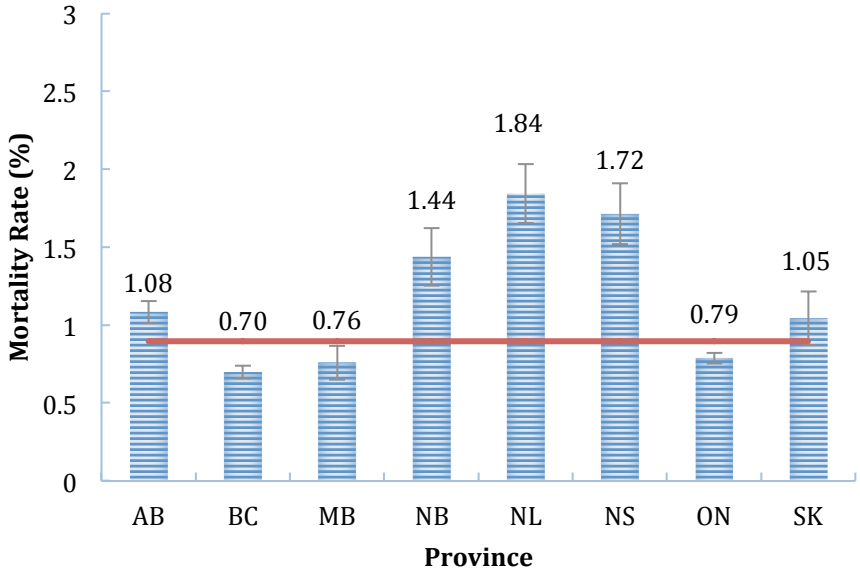


Figure 4.2.5g: Age-adjusted mortality rates for ovarian cancer surgeries (2004-12)

In univariate analysis, hospital volume was significantly associated with mortality rate (Figure 4.2.4h). These outcomes persisted even after controlling for provincial differences unaccounted for in the model. There were non-significant differences between obstetrics/gynecologists and gynecological oncologists for in-hospital mortality, while general surgeons had a significantly higher risk of in-hospital mortality. A non-significant association between surgeon volume and risk of in-hospital mortality was observed. Higher age, co-morbidity score, and the addition of bowel resections for complete resection predicted a significantly higher risk of mortality. There were no significant differences in

mortality risk found over time (years), between different procedures, or between Ontario and rest of the country.

- ***After adjusting for patient-specific factors, procedure type, and hospital random effects, an increase of 10 ovarian cancer resections per institution in a given year was associated with 7% reduction in the risk of in-hospital mortality.***

- ***Assuming that the quality of care and outcomes are the same across all the hospitals in the highest volume tercile, theoretically a total of 48 additional lives could have been saved after ovarian cancer surgeries in Canada (2004-12).***

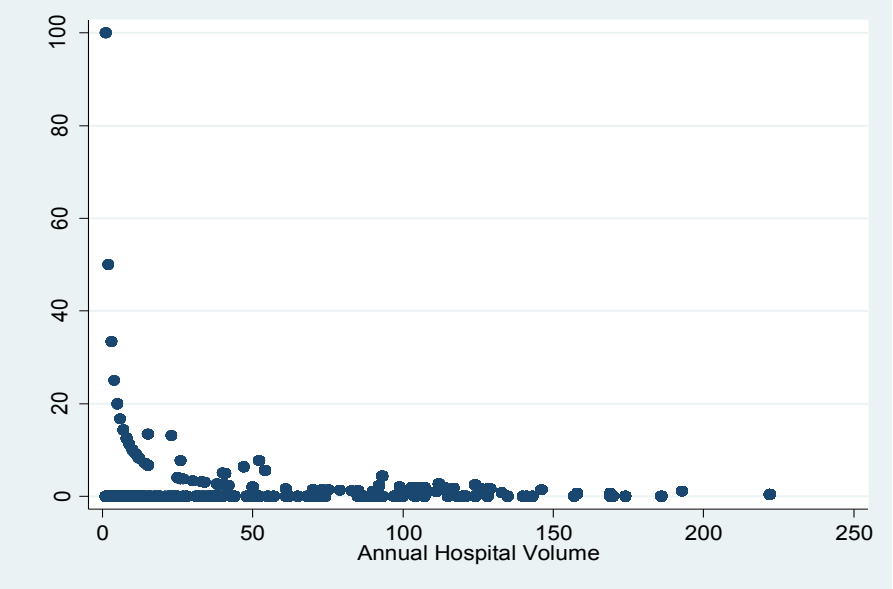


Figure 4.2.5h: Annual hospital volume and mortality rate (%) for ovarian cancer surgeries (2004-12)

Length of Stay

For ovarian cancer surgery, the overall median length of stay was 4 days [IQR=3-6]. There were only minute differences between the provinces for length of hospital stay. Nova Scotia, Saskatchewan, New Brunswick, and Newfoundland had the highest (5 days), whereas British Columbia had the lowest median length of stay (3 days) (Table 4.2.5b). No variations in median length of stay were observed over time (Table 4.2.5c). Omentectomy and open procedures (oophorectomy, fallopian tube resection, simple hysterectomy) showed a strong association between higher facility volume and increased discharge rate (Figure 4.2.5i).

TABLE 4.2.5B: MEDIAN LENGTH OF STAY

Province	Median Length of Stay [IQR]
AB	4 [3]
BC	3 [3]
MB	4 [3]
NB	5 [5]
NL	5 [3]
NS	5[4]
ON	4 [3]
SK	5 [4]

Patient-related factors, bowel resections and an increasing number of combined gynecological resections during the same operation predicted a significantly higher length of stay. Similarly, compared to minimally invasive oophorectomy, the risk of longer hospitalization was higher for all other resection types. A higher annual hospital volume was significantly associated with lower length of stay, as opposed to higher surgeon volume that was associated with a higher risk of prolonged hospitalization. There were non-significant differences between obstetrician/gynecologists and gynecological oncologists, however, general surgeons had significantly higher risk of longer length of stay. Moreover, non-significant differences existed between the Ontario and rest of the country in the number of hospital days post ovarian cancer resections.

TABLE 4.2.5C: MEDIAN LENGTH OF STAY IN CANADA, BY YEAR

	Fiscal Year								
	2004	2005	2006	2007	2008	2009	2010	2011	2012
Median Length of Stay [IQR]	4[4]	4[3]	4[3]	4[3]	4[3]	4[3]	4[2]	4[3]	4[2]

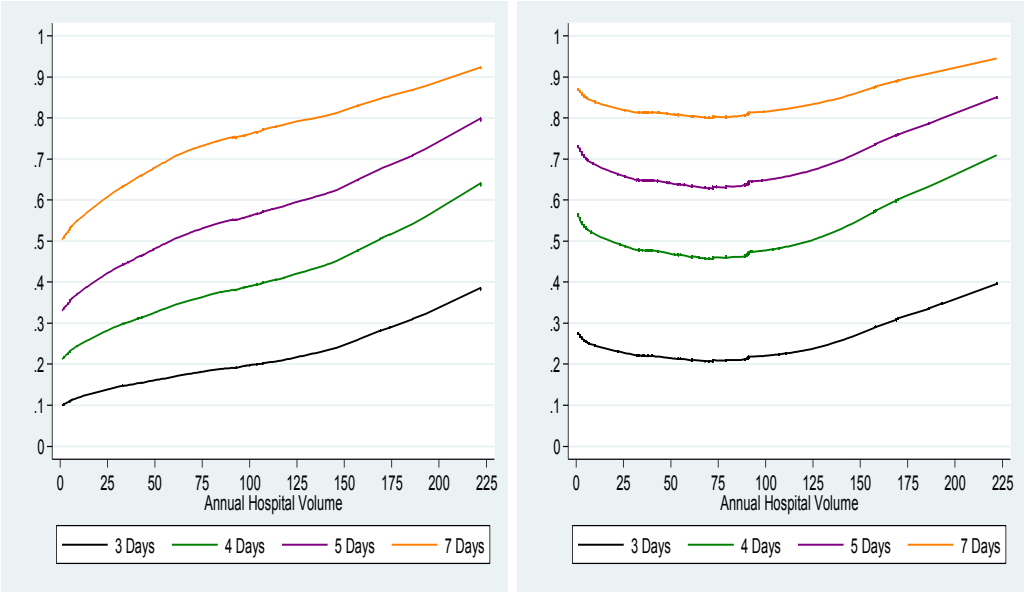


Figure 4.2.5i: Predicted discharge rate after a. Omentectomy, b. Open Oophorectomy/Simple Hysterectomy (2004-12)

- ***There were no differences in median number of hospital days between hospitals in lowest and highest volume categories.***

5.0: REGIONALIZATION: PROVINCIAL CASE STUDIES

CHAPTER HIGHLIGHTS

- The review of literature and published policies of health care delivery organizations shows that at the present time, there are no published pan-Canadian standards for the delivery of high risk cancer surgeries
- Discrepancies were found between the provinces with regard to the approaches undertaken to provide surgical cancer care. Given the varying geographic, political, and economic differences between the different provinces, it is rather impractical to have one set of standards for every jurisdiction.
- Passive centralization has occurred in most provinces (other than Ontario) despite not having a formal regionalization strategy
- There appears to be minimal regulation at the provincial level for organization of delivery structure, and availability of published guidelines to ensure standardization of high quality care.
    - Ontario is the only province with specific externally published standards and guidelines for directing high risk surgical procedures to designated centres
- The key informant interviews revealed a lack of accountability in most of the country; inability to enact change; or a formal process to track and evaluate outcomes of surgical care
- The most striking finding of this pan-Canadian analysis is the tremendous variance in care across the country. In many of the surgeries evaluated, the mortality difference between the provinces with the lowest and highest mortality rates shows an **increase of mortality of three to four times**. Similarly, the length of stay can vary by 2-3 days on average per patient depending on where the procedure is performed. By opting for regionalization policies, **not only could we influence mortality but we could do it in a more efficient and cost effective manner.** These results are clinically striking and statistically significant as well, which further emphasizes their significance.
- Particularly in the case of ovarian cancer, the current state of care seems to be very much in need of a regionalization effort. It has half the number of cases nationally as lung cancer, but three times the number of institutions performing these surgeries with many of the centres reporting a very small total annual case volume. Considering the demonstrated improvements in mortality rates from regionalization to high volume centres, it encourages health care planners to consider addressing this issue along with topic experts and regional health system stakeholders through the implementation of regionalization policies.

5.1 OVERVIEW

In this section, an insight into the structures of care for the delivery of cancer surgical procedures is presented along with reports of outcomes compared to the national average. In the absence of available reporting on policies and standards in place for the delivery of complex cancer surgeries, structured interviews were conducted with experts across Canada to gain their perspective on the delivery and organization of surgical cancer care in their respective province. The participants included practicing surgeons, heads of surgical oncology, or stakeholders who are involved with decision making for cancer surgical care. Provincial report cards are presented to allow for intra- and inter-provincial comparisons on mortality, length of stay, and travel times based on the latest available data. The rates of mortality, median length of stay and travel times for provinces with smaller population sizes are subject to large variations. For instance, if twenty esophagectomies are performed in a province, only one instance of mortality can increase the mortality rate from 0% to 5%. Therefore, 3-year crude averages for the primary outcomes are presented to draw fair comparisons. Similarly, a number of hospitals across Canada performed only one surgery per year, which affected the total number of institutions performing surgeries in a given year. For the purpose of addressing the large range of institutional volumes and random variation within a given hospital, a count of facilities with an annual volume of >5 was also stated. The discussion below is intended to be used by stakeholders to broaden their understanding of current organizational structures of surgical care and associated patient-based outcomes in their respective provinces.

5.2 ALBERTA

Alberta Health Services directly oversees the structure of the entire health care system in the province, including the delivery of the five cancer surgeries under discussion in this report. The province is further divided into 6 zones. Cancer Control Alberta oversees the cancer centre-based delivery of chemotherapy and radiotherapy oncological services. The zones are authorized to oversee cancer care, including surgical cancer care within their jurisdiction, working together with the institutions undertaking the procedures. Alberta is described as having an asymmetric bipolar structure of care, with the South zone managing a significant portion of the total provincial surgical volume and equipped with a broader infrastructure for delivering surgical cancer services. Recognizing the need for a provincial body for policy-related decisions concerning cancer surgical care, the "Strategic Clinical Network" has been established in association with Alberta Health Services.

Overall, it appears that Alberta has some quality improvement initiatives underway, but there is nothing specifically with regards to ‘active’ regionalization or the implementation of policy guidelines for the cancer types under discussion in this report. Based on conversations with key informants, it appears that there has been passive regionalization for some surgical procedures as a result of steps taken by individual surgeons to open

surgical centres. Table 5.1 provides evidence for some form of consolidation of esophagus, lung, and liver surgeries with an attendant increase in the number of resections.

The number of resections carried out in 2012 was higher than the 3-year provincial average for all procedures. Ovarian cancer surgeries had the second highest volume in the province, yet they appear to be least centralized. Only three institutions had a volume greater than five in 2012, whereas two centres undertook greater than 90 resections. The crude, 3-year mortality rates appear to be higher than the national average for pancreatic and ovarian cancer procedures. Similarly, the median length of stay was higher than the national average for all but ovarian cancer resections, which indicates room for improvement. The travel distance was more than twice longer for esophagectomies as compared to the other procedures, with the lowest (49%) proportion of patients within one-hour commute.

TABLE 5.1: STATE OF HIGH-RISK SURGERIES IN ALBERTA

	Esophagus	**Pancreas**	**Liver**	**Lung**	**Ovarian**
# Surgeries in 2012 (Average 2010-12)	49 (44)	111 (96)	224 (184)	403 (370)	261 (251)
# Hospitals in 2012 (# with Case Volume >5)	4 (2)	7 (2)	5 (3)	2 (2)	16 (3)
Mean Hospital Case Volume in 2012 (range)	12 (2-33)	16 (1-60)	44 (1-130)	202 (131-272)	16 (1-124)
% Mortality Rate (2010-12)	2.29	4.17	2.35	1.62	1.46
% Mortality Rate National Average (2010-12) (Standard Error)	4.74 (0.68)	2.90 (0.42)	2.63 (0.27)	1.63 (0.12)	0.74 (0.11)
Median LOS [IQR] (2010-12)	15 [12]	11 [8]	8 [6.5]	6 [5]	4 [3]
Median LOS National Average [IQR] (2010-12)	13 [10]	10 [9]	7 [5]	5 [4]	4 [2]
Median Travel Distance (2010-12) Kilometers [IQR]	47 [160]	22 [165]	18 [144]	18 [118]	17 [96]
% of patient in 1-hour travel time (2010-12)	49	57	62	62	65

5.3 BRITISH COLUMBIA

The British Columbia Cancer Agency (BCCA) does not have a formal role in regulating the structure and delivery of cancer surgical care. The BCCA plays a supporting role in improving the quality of surgical care in the province. For instance, a 'Surgical Oncology Network' has been established to improve coordination and communication between oncology service providers and the surgeons, in addition to connecting these surgery providers with the BCCA. The Surgical Oncology Network has different committees that aid in the planning, support, and implementation of its strategic initiatives, including the development and implementation of clinical practice guidelines, continuing professional development, knowledge transfer, and research and outcomes evaluation.

The key informant interviews revealed that the thoracic cancer surgeries have been formally regionalized in British Columbia with minimum direct involvement from the BCCA. However, the BCCA appears to have recently played a significant role in the centralization of gynecological surgeries. In one of the thoracic surgical cancer care centres in Kelowna, the initial assessments are completed via video-conferencing with surgical teams to help ameliorate some of the significant travel burden that would otherwise limit access to surgical care for remote patients. This example of innovation may be helpful for jurisdictions looking to limit the impact of regionalization policies on patients.

The analysis of data shows that British Columbia appears to have managed the increasing volume of lung, liver, and esophageal procedures by consolidating surgical care into four large volume centres. The annual number of procedures for pancreatic, liver, and lung cancer was higher than the 3-year provincial average implying an increasing case load. Overall, the 3-year mortality rates were lower than the national average for all the procedures under investigation. The number of institutions performing less than 5 cases annually may present with potential room for improvement. For instance, a total of 31 institutions carried out ovarian cancer surgeries but only eight of these centres were conducting more than five resections in 2012 (Table 5.2). This number does not represent the vast case volume differences across these eight institutions, which had a case load ranging from 6 to 174 surgeries. Similarly, five of nine institutions performed a small number of pancreatic procedures. Although the 3-year crude mortality rate was over 5 times less than the national average, the median length of stay was higher than the national average for pancreatic cancer procedures. Similarly, the mortality rates were roughly 50% less than the national average for ovarian and esophageal procedures, with a median length of stay lower than the national average. Each of the procedures was generally within an hour travel time for a majority of the patients. The higher number of institutions performing ovarian procedures could account for shortest travel burden on the patients for these resections.

TABLE 5.2: STATE OF HIGH-RISK SURGERIES IN BRITISH COLUMBIA

	Esophagus	Pancreas	Liver	Lung	Ovarian
# Surgeries in 2012 (Average 2010-12)	66 (64)	92 (77)	221 (208)	614 (550)	331 (341)
# Hospitals in 2012 (# with Case Volume >5)	6 (4)	9 (4)	5 (4)	4 (4)	31 (8)
Mean Hospital Case Volume in 2012 (range)	11 (1-21)	10 (1-53)	44 (1-144)	154 (102-224)	11 (1-174)
% Mortality Rate (2010-12)	2.60	0.43	2.40	1.09	0.39
% Mortality Rate National Average (2010-12) (Standard Error)	4.74 (0.68)	2.90 (0.42)	2.63 (0.27)	1.63 (0.12)	0.74 (0.11)
Median LOS [IQR] (2010-12)	11 [9]	12 [10]	7 [5]	5 [4]	3 [2]
Median LOS National Average [IQR] (2010-12)	13 [10]	10 [9]	7 [5]	5 [4]	4 [2]
Median Travel Distance (2010-12) Kilometers [IQR]	28 [88]	28 [59]	20 [60]	25 [93]	17 [47]
% of patient in 1-hour travel time (2010-12)	57	57	62	58	68

5.4 MANITOBA

Health care delivery in Manitoba has been organized by the five Regional Health Authorities (RHA) since 2012, with Cancer Care Manitoba (CCMB) responsible for overseeing cancer services within the province. Cancer care consists of a primary facility in Winnipeg and a secondary institution located in Brandon. Given the presence of two major cancer treatment centres in the province, the surgical care seems to be 'passively' centralized. There is one institution in Winnipeg managing the highest case load for all five high-risk cancer surgeries. Based on our discussions with expert surgeons in the region, there is evidence of planned consolidation of thoracic cancer surgeries. In 2007, all thoracic surgeries were moved to a single centre in Winnipeg, with only a small number of thoracic surgeries still carried out in Brandon.

The number of surgeries for all five cancers did not show much deviance from the 3-year provincial average. A strong trend for consolidation of surgical care to a small number of institutions is evident for all five cancer procedures. For instance, only one institution was performing liver resections in 2012, down from four in 2004. Likewise, the number of

institutions performing ovarian cancer surgeries was down from ten to five over the study period. In spite of apparent centralization of surgical care, the median travel distances remained close to 15 kilometers for all surgeries. There were small variations in the proportion of patients who travelled less than an hour for surgical care across all the procedures. About 70% of the patients for ovarian cancer surgeries travelled less than an hour, compared to 53% for esophageal cancer procedures.

The case study of Manitoba presents with an interesting scenario. The 3-year crude mortality rate for esophageal cancer resections was more than three times that of the national average, whereas the median length of stay was 2 days higher (Table 5.3). Some of the variation in mortality rate could be explained by the small total provincial case load leading to significant year over year variance; however it may also emphasize the significance of factors other than hospital volume on patient outcomes (i.e. surgeon specialty, staff training). A lack of available data on such measures limits our ability to comment on the observed differences in the rate of mortality for esophageal resections. Pancreatic resection data reported a mortality rate and length of stay higher than the national average in spite of the fact that these resections were carried out in only 2 institutions.

TABLE 5.3: STATE OF HIGH-RISK SURGERIES IN MANITOBA

	Esophagus	**Pancreas**	**Liver**	**Lung**	**Ovarian**
# Surgeries in 2012 (Average 2010-12)	16 (12)	31 (27)	55 (55)	226 (233)	109 (114)
# Hospitals in 2012 (# with Case Volume >5)	2 (1)	2 (2)	1 (1)	2 (2)	5 (3)
Mean Hospital Case Volume in 2012 (range)	8 (2-14)	16 (8-23)	55 (55)	113 (13-213)	21 (1-62)
% Mortality Rate (2010-12)	16.67	5.0	2.42	1.29	0.58
% Mortality Rate National Average (2010-12) (Standard Error)	4.74 (0.68)	2.90 (0.42)	2.63 (0.27)	1.63 (0.12)	0.74 (0.11)
Median LOS [IQR] (2010-12)	15 [13]	13 [11.5]	7 [4]	4 [3]	4 [3]
Median LOS National Average [IQR] (2010-12)	13 [10]	10 [9]	7 [5]	5 [4]	4 [2]
Median Travel Distance (2010-12) Kilometers [IQR]	14 [104]	16 [94]	13 [85]	13 [94]	12 [53]
% of patient in 1-hour travel time (2010-12)	53	59	64	63	70

5.5 NEW BRUNSWICK

New Brunswick is divided into 2 Regional Health Authorities (RHAs), which serve the Anglophone and Francophone populations. Although the various cancer services are coordinated by the New Brunswick Cancer Network, the delivery and organization of surgical care seems to be the responsibility of the RHAs and the provider institution. By nature of relatively small geography, surgery in New Brunswick operates out of a small number of centres and has a small total surgical case load. Overall, higher volume centres were located in Moncton, Fredericton, St. John, and Edmundston. There is an obvious overlap between institutions performing resections for all five cancer types. Based on our interviews with key informants, there does not appear to be any formal centralization initiatives directed specifically towards cancer surgeries.

New Brunswick had smallest number of resections of all the provinces. Therefore, year over year fluctuations in the number of surgeries also affected the number of institutions performing surgeries annually. Although a variation in number of facilities was observed over time, it could mainly be a result of year-over-year fluctuations in the number of surgeries. For instance, the number of institutions for pancreatic cancer reduced from six in 2004 to three in 2012 (Table 5.4). However, it is unclear whether the reduction in the number of surgical institutions was a planned move or a result of random fluctuations in the number of resectable cases within that facility catchment area. Small variations in the number of surgeries were observed over the most recent 3-year period. None of the institutions for liver, esophagus, and pancreatic cancer had a case volume greater than five in 2012. The 3-year, crude mortality rate was smaller than the national average for all cancer resections except lung. The median length of stay was smaller than the national average only for esophageal cancer. However, small case volumes limit our ability to present a valid comparison between the national average and New Brunswick data. The province might be better compared with other provinces with small case load and relatively large geographic catchment areas. Similarly, the travel times show vast differences between the different cancer types, but the large interquartile ranges demand caution when interpreting these results.

TABLE 5.4: STATE OF HIGH-RISK SURGERIES IN NEW BRUNSWICK

	Esophagus	Pancreas	Liver	Lung	Ovarian
# Surgeries in 2012 (Average 2010-12)	13 (10)	9 (9)	6 (7)	213 (200)	57 (61)
# Hospitals in 2012 (# with Case Volume >5)	5 (0)	3 (0)	4 (0)	6 (6)	7 (2)
Mean Hospital Case Volume in 2012 (range)	2 (1-5)	3 (2-4)	1.5 (1-3)	36 (6-63)	8 (1-38)
% Mortality Rate	3.23	0	0	2.16	0.54

(2010-12)					
% Mortality Rate National Average (2010-12) (Standard Error)	4.74 (0.68)	2.90 (0.42)	2.63 (0.27)	1.63 (0.12)	0.74 (0.11)
Median LOS [IQR] (2010-12)	12 [6]	11 [14]	8 [3]	7 [5]	5 [3]
Median LOS National Average [IQR] (2010-12)	13 [10]	10 [9]	7 [5]	5 [4]	4 [2]
Median Travel Distance (2010-12) Kilometers [IQR]	20 [41]	102 [146]	33 [124]	48 [115]	58 [177]
% of patient in 1-hour travel time (2010-12)	65	35	55	45	41

5.6 NEWFOUNDLAND AND LABRADOR

Newfoundland and Labrador's health care system is governed by the Department of Health and Community Services. There are four Regional Health Authorities in the province, who are responsible for health care delivery within their jurisdictions. Similar to New Brunswick, Newfoundland has a small case volume for all five cancer resections. These procedures appear to be performed in one central location in St. John's, except for a small number of resections performed by other institutions for ovarian cancer. Therefore, it appears that there has been an informal process of consolidation of services within the province. According to our experts, hepatic and thoracic resections are performed only in St. John's. Although Eastern Health was the biggest, stand-alone provincial body, it was mostly involved with the coordination of medical and radiation oncology services, with no comparable organization with a provincial mandate to oversee cancer surgical care across the four regional health authorities. The hospital(s) undertaking the surgeries were the groups primarily responsible for making decisions concerning surgical care, including the scope of practice for surgeons.

According to the analysis of provincial data, the 3-year mortality rates were higher than the national average for esophagus and lung resections but the small number of cases does not present a fair comparison (Table 5.5). The median length of stay was 3 days more than the national average for pancreatic and lung resections. The potential impact of the consolidation of care to one large centre is visible in longer patient travel distances for esophageal, pancreatic, liver and lung cancers. Six institutions performing ovarian resection do not appear to have resulted in higher mortality rates and have retained a short patient travel distance in Newfoundland and Labrador.

TABLE 5.5: STATE OF HIGH-RISK SURGERIES IN NEWFOUNDLAND AND LABRADOR

	Esophagus	Pancreas	Liver	Lung	Ovarian
# Surgeries in 2012 (Average 2010-12)	3 (4)	13 (9)	29 (21)	49 (59)	53 (46)
# Hospitals in 2012 (# with Case Volume >5)	2 (0)	1 (1)	1 (1)	1 (1)	6 (1)
Mean Hospital Case Volume in 2012 (range)	1.5 (1-2)	13 (13)	29 (29)	49 (49)	8 (1-43)
% Mortality Rate (2010-12)	8.33	0	0	1.69	0
% Mortality Rate National Average (2010-12) (Standard Error)	4.74 (0.68)	2.90 (0.42)	2.63 (0.27)	1.63 (0.12)	0.74 (0.11)
Median LOS [IQR] (2010-12)	13 [11]	13 [22]	7 [5]	8 [4]	4 [2]
Median LOS National Average [IQR] (2010-12)	13 [10]	10 [9]	7 [5]	5 [4]	4 [2]
Median Travel Distance (2010-12) Kilometers [IQR]	146 [422]	272 [405]	95 [286]	292 [539]	25 [149]
% of patient in 1-hour travel time (2010-12)	33	25	40	30	56

5.7 NOVA SCOTIA

Cancer Care Nova Scotia is the provincial cancer agency that is involved with setting overall standards for cancer care, except in the delivery of surgical cancer care. For more than a decade, surgical cancer care has primarily been organized by each of the nine District Health Authorities who are responsible for health care service planning and allocation for residents within the region as well as neighbouring Atlantic provinces. Except for the reporting of surgical wait times, the provincial oversight for surgical care is minimal. It is also unclear how the planned move to single provincial health authority (in April 2015) for adult clinical care will impact delivery of cancer surgical care. The major cancer surgical centres in Nova Scotia are located in Halifax and Sydney. The available data and expert opinion supports passive regionalization of surgical care to 1 or 2 major surgical centres in Halifax and Sydney.

The annual case volume did not show much deviance from the 3-year provincial average (2010-2012), and neither did the number of institutions from 2004-2012 (Table 5.6). Except for ovarian cancer, a majority of surgeries were carried out in two major centres.

High 3-year crude mortality rates for liver, pancreatic, and ovarian cancers present with an interesting discussion and an opportunity for improvement. Outcomes of esophageal and lung surgeries were better than the national average, although the number of cases for were too small for a meaningful comparison. The added burden of travel with higher risk of mortality for pancreatic and liver resections may point towards a need for improvements in care processes.

TABLE 5.6: STATE OF HIGH-RISK SURGERIES IN NOVA SCOTIA

	Esophagus	Pancreas	Liver	Lung	Ovarian
# Surgeries in 2012 (Average 2010-12)	14 (16)	16 (19)	71 (68)	176 (192)	91 (85)
# Hospitals in 2012 (# with Case Volume >5)	2 (1)	1 (1)	3 (1)	2 (2)	10 (1)
Mean Hospital Case Volume in 2012 (range)	7 (4-10)	16 (16)	24 (1-69)	88 (13-163)	9 (1-71)
% Mortality Rate (2010-12)	0	5.36	3.45	0.87	1.18
% Mortality Rate National Average (2010-12) (Standard Error)	4.74 (0.68)	2.90 (0.42)	2.63 (0.27)	1.63 (0.12)	0.74 (0.11)
Median LOS [IQR] (2010-12)	12 [9]	12 [17]	7 [5]	5 [3]	4 [2]
Median LOS National Average [IQR] (2010-12)	13 [10]	10 [9]	7 [5]	5 [4]	4 [2]
Median Travel Distance (2010-12) Kilometers [IQR]	93 [282]	115 [292]	193 [280]	71 [148]	51 [187]
% of patient in 1-hour travel time (2010-12)	44	36	31	45	48

5.8 ONTARIO

In Ontario, health care planning and delivery is coordinated by fourteen Local Health Integration Networks, with cancer care coordinated by Cancer Care Ontario (CCO). Through initiatives led by CCO, Ontario has taken the most formal, active, and clearly defined approach to the regionalization of high-risk complex cancer surgery in Canada. With respect to the cancers evaluated in this report, CCO has implemented evidence-based guidelines and standards for thoracic and hepatopancreatobiliary cancers, while the guideline development process for ovarian cancer was initiated in 2010 and implementation is currently under way.

Pancreatic cancer surgical regionalization started in 1999 and continued through the early 2000s, while thoracic surgery initiated the regionalization process in Ontario starting in 2004-2005. This complex multifaceted undertaking was not instantaneous, but over time led to the consolidation of case volume through the successful implementation of explicit and financially supported regionalization policies as outlined by CCO (www.cancercare.on.ca). To support this process of regionalization, practice standards were established in an evidence-based manner to clearly delineate definitions of high volume centres, minimum institutional requirements such as the availability of surgical step down units or training requirements for surgeons, and other key components to promoting high quality care. Communities of practice for each specialty were encouraged to participate in the development and implementation of these standards, but also to set national priorities and facilitate the transfer of knowledge.

This regionalization work is reflected in the observed lower number of institutions offering these cancer surgeries and higher mean surgeon case volumes relative to those reported in much of Canada. Despite this active management of regionalization in Ontario, there are still a number of smaller centres and presently unregionalized cancers such as ovarian cancer that persist. This speaks to the great challenges facing governing bodies as they implement quality improvement initiatives.

With regards to the province-specific outcomes and travel times in Ontario, most metrics are comparable to the rest of Canada. The travel times for most cancers are reasonable for most patients, with the vast majority of patients able to access surgical care within the hour threshold, although esophageal cancer care sees times that tend to exceed one hour. The length of stay for all cancers is at or below the national averages. The 3-year mortality rates for most operations are near the national average, but this may be a result of a sampling bias as Ontario represents roughly 50% of all the total surgical cases performed across Canada in most of the cancers evaluated (Table 5.7).

A better evaluation of regionalization in Ontario may be to compare mortality rates over time relative to the rest of the country, which largely had minimal formal regionalization policies (although province-specific undertakings are outlined accordingly in this section). This is reported in Figure 5.7. At face value, the pancreatic mortality is comparable to the non-regionalized cases over time. When evaluating this number, one has to keep in mind that the surgeries in Ontario were largely regionalized by this period of time and interestingly, there is a disproportionate rise in case volume in Ontario compared to the rest of the country. The mortality rates may be influenced by a greater number of cases, which would naturally result in a larger raw number of deaths, although it is difficult to ascertain for certain with administrative data. The results for lung cancer surgery, liver and esophagus are more complex in nature. The crossing curves make statistical analysis difficult. This analytical challenge notwithstanding, it does appear that the results are

inferior to the national statistics although multivariate regression analysis does not show significance. For lung cancer, the most regionalized cancer type in the time period studied, the mortality in Ontario seems to converge with the rates for the rest of Canada.

Generally speaking, it is difficult to measure differences when a series of measures are undertaken over time. Very different results could be found if Ontario was evaluated the day after the policies were published or if some duration of time was allowed to pass before initiating evaluation to allow processes to become streamlined and fully integrated into the health care system. Overarching this evaluation issue, there has been a considerable number of other changes in the health system that could be confounding the results. Another plausible explanation for differing mortality observations is that there is an increased number of patients receiving curative resections in Ontario (See Chapter 4). Resection rate is a combination of cancer stage at time of presentation, indications for surgery and technical considerations. Regionalization, in theory, facilitates collaboration between highly trained surgeons while also encouraging the development of specialized staff and infrastructure that may allow patients with a higher stage disease or more complex co-morbidities to undergo resection in Ontario. The higher risk of mortality may be resultant from this increased patient complexity. With this said, it is important to remember that this is just a hypothetical explanation for the observed findings.

In this context, mortality and length of stay have both fallen over time, and the attributable component of regionalization to this is undeterminable. Perhaps the greatest impact of regionalization can be found in more subjective measures that are difficult to measure such as adherence to guidelines, appropriate surgical decision making, or effective utilization of medical and radiation oncology to name a few. Over time, an improvement in care across many domains of cancer care has been observed, but there continues to be a tremendous variability in outcomes. In the Ontario example, there has been a tightening of this variance, which allows for more consistent care. Overall, these outcomes provide a complex and unanswerable series of questions. What does appear to be missing in the Ontario experience is quality feedback loops on facility specific outcomes.

The Ontario regionalization experience serves as a robust, if not complex, model of implementation of regionalization for the rest of Canada. The large population of Ontario, the geographic density and infrastructure are not necessarily transferrable, but the lessons learned from successfully implementing these significant structural changes despite the challenges can serve to provide lessons for other future adopters. Given that Ontario has utilized a multi-focal approach to actively implementing regionalization, it is impossible to dissect out the impact of regionalization on the quality of patient care in isolation, but as a whole, Ontario's regionalization activities appear to have positively affected the delivery of care.

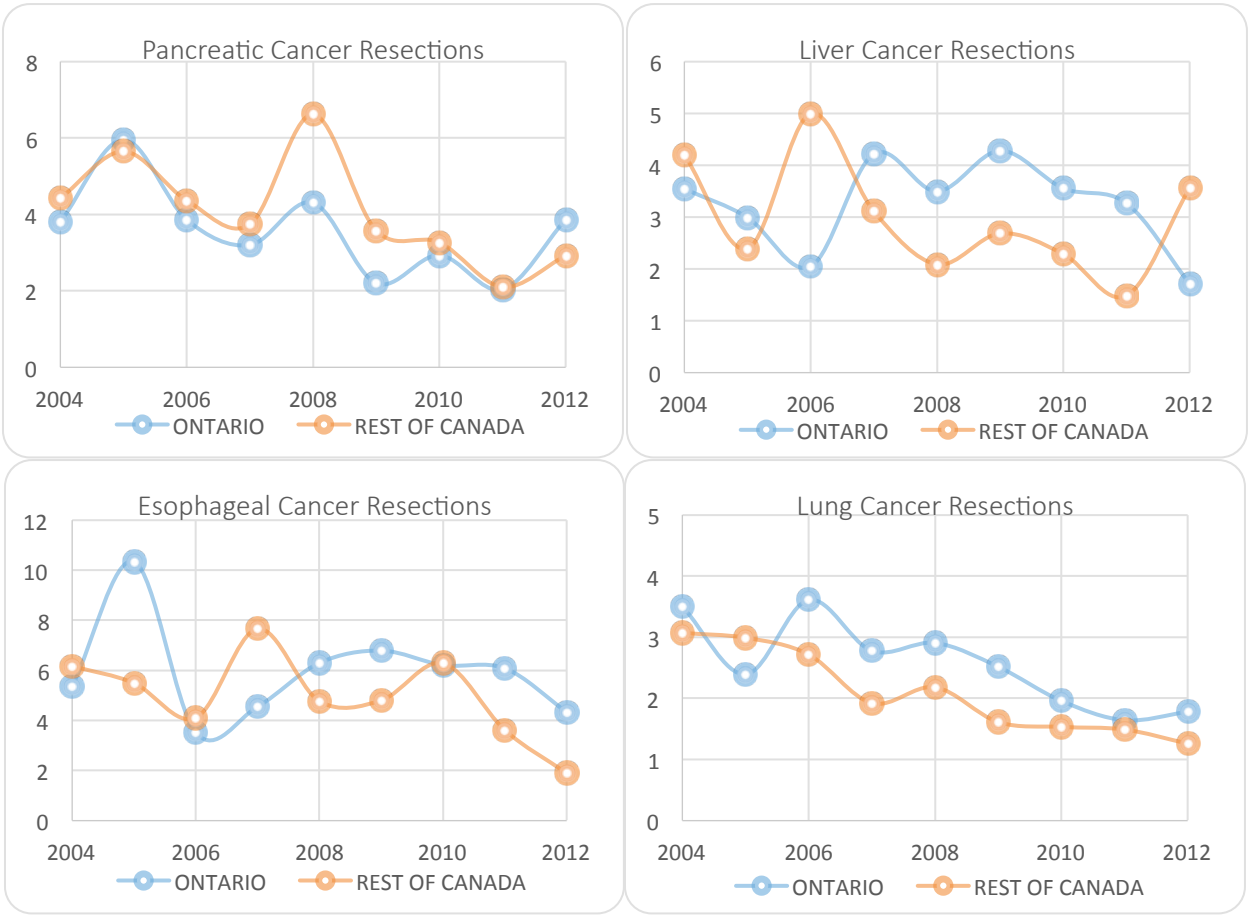


Figure 5.7 Age-adjusted Mortality Rates Ontario vs. Rest of Canada (2004-12)

TABLE 5.7: STATE OF HIGH-RISK SURGERIES IN ONTARIO

	Esophagus	Pancreas	Liver	Lung	Ovarian
# Surgeries in 2012 (Average 2010-12)	161 (165)	316 (280)	638 (583)	1964 (1819)	1054 (986)
# Hospitals in 2012 (# with Case Volume >5)	15 (9)	13 (9)	20 (11)	24 (17)	63 (21)
Mean Hospital Case Volume in 2012 (range)	11 (1-32)	24 (1-93)	32 (1-149)	81 (1-292)	17 (1-222)
% Mortality Rate (2010-12)	5.65	2.98	2.86	1.83	0.68
% Mortality Rate National Average (2010-12) (Standard Error)	4.74 (0.68)	2.90 (0.42)	2.63 (0.27)	1.63 (0.12)	0.74 (0.11)
Median LOS [IQR] (2010-12)	12 [11]	9 [7]	7 [4]	5 [3]	4 [2]
Median LOS					

National Average [IQR] (2010-12)	13 [10]	10 [9]	7 [5]	5 [4]	4 [2]
Median Travel Distance (2010-12) Kilometers [IQR]	31 [79]	32 [76]	31 [72]	26 [69]	25 [54]
% of patient in 1-hour travel time (2010-12)	61	61	57	63	67

5.9 PRINCE EDWARD ISLAND AND TERRITORIES

The health system in Prince Edward Island is operated by Health PEI, a single subsidiary of the provincial government. There is a single cancer centre on the island, although the majority of relevant cancer surgeries were transferred to institutions in New Brunswick or Nova Scotia. The territories also follow a similar pattern of referral to other provinces for their surgical cancer cases. Surgeries for residents in Yukon were performed in either British Columbia or Alberta for all five cancers except for esophageal cancer surgeries that were performed in British Columbia. Ontario, Manitoba and Alberta undertook surgeries for residents in Nunavut and Northwest Territories. All four jurisdictions have extremely small caseloads, so it would be inappropriate to perform any comparisons.

5.10 SASKATCHEWAN

The cancer surgical care in Saskatchewan is overseen by the "Surgical Initiative Branch" of Saskatchewan Ministry of Health. Saskatchewan Cancer Agency (SCA) does not have a role in the organization of oversight of surgical care in the province. Our best efforts could not capture any information regarding regionalization, control of surgical volume, and/or creation of designated surgical centres. However, there are reports of initiatives taken in 2009 to improve surgical care and reduce wait times for certain surgical procedures, including cancer surgery. As part of this initiative, a specialist directory has been made available online that provides information on types of surgical procedure, the case volume, and wait times for last 12 months at each of the provider sites in their respective health regions. This is an example of the initiation of transparency of information policies that are aimed at improving system performance.

The annual case volume for four of the five cancer types seems to be decreasing, and along with it, the number of facilities providing surgical care (Table 5.8). For instance, the number of institutions providing liver cancer surgery dropped from 4 centres to 2, and from 3 to 2 for lung resections from 2004 to 2012. These institutions were concentrated in Saskatoon and Regina. It was unclear if the reduction in the number of institutions was related to random variations associated with the small number of cases, or an intent to consolidate these services. Other institutions either had very low volume or there is an evidence of consolidation. Still, there is more room for institutions in Saskatchewan to switch to one

centre as illustrated by the case volume for ovarian procedures being less than half of lung resections, yet nine institutions performed such operations as compared to two for lung cancer. A majority of institutions had a case volume less than five per year. Interestingly, the 3-year average mortality rates were higher than the national average for all the procedures, except pancreatic cancer. The median length of stay over the same time period was higher than national average for all procedures, however. Higher travel times for esophagus and pancreatic procedures might be a result of consolidation of such services to a few centres, but same was not true for liver cancer resections. A large number of institutions for ovarian resections could explain shorter travel distances for these procedures in Saskatchewan.

TABLE 5.8: STATE OF HIGH-RISK SURGERIES IN SASKATCHEWAN

	Esophagus	**Pancreas**	**Liver**	**Lung**	**Ovarian**
# Surgeries in 2012 (Average 2010-12)	12 (15)	11 (12)	20 (24)	150 (135)	69 (84)
# Hospitals in 2012 (# with Case Volume >5)	2 (1)	3 (0)	2 (1)	2 (2)	9 (3)
Mean Hospital Case Volume in 2012 (range)	6 (1-11)	4 (2-5)	10 (2-18)	75 (53-97)	8 (1-33)
% Mortality Rate (2010-12)	6.67	2.70	2.78	1.97	0.79
% Mortality Rate National Average (2010-12) (Standard Error)	4.74 (0.68)	2.90 (0.42)	2.63 (0.27)	1.63 (0.12)	0.74 (0.11)
Median LOS [IQR] (2010-12)	14.5 [9]	14 [12.5]	9 [7]	6 [4]	5 [5]
Median LOS National Average [IQR] (2010-12)	13 [10]	10 [9]	7 [5]	5 [4]	4 [2]
Median Travel Distance (2010-12) Kilometers [IQR]	162 [229]	155 [204]	72 [216]	73 [186]	50 [161]
% of patient in 1-hour travel time (2010-12)	29	35	50	46	52

6.0: CITIZEN ENGAGEMENT

CHAPTER HIGHLIGHTS

- Regionalization of high-risk, complex cancer services is fraught with potential impacts to patients and caregivers; therefore, it is necessary to consider the thoughts of these potential users of the system.

Principal Findings

- The citizen panels highlighted that the regionalization of complex cancer surgeries into regionalized, high-volume centres may be the most promising approach to improving outcomes related to the delivery of care. Indeed, the number of panel members who ranked regionalization as the most important option increased consistently across all three panels from pre- to post-deliberations, which suggests an increased strength in their preference for this option as a result of developing a clearer understanding of regionalization through discussions. Figure 6.0 visually demonstrates this trend.

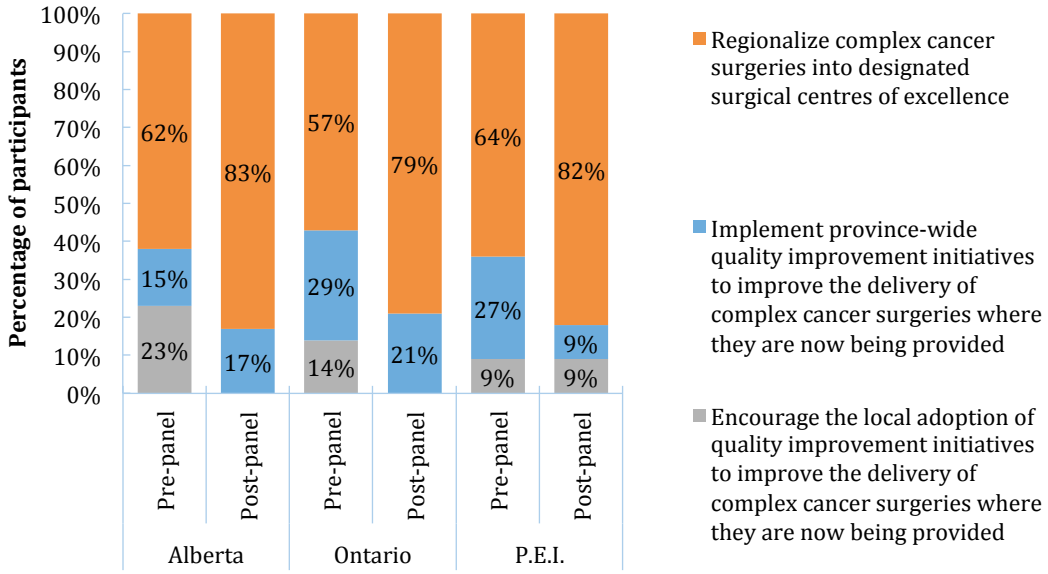


Figure 6.0: What is the most favoured option to improve the delivery of complex cancer surgeries in Canada?

- Panel deliberations revealed that in an optimal situation, patients would receive regionalized surgical cancer care in centres of excellence, yet complete pre- and post- operative investigations closer to home in either local centres or via telemedicine programs to allow for access with highly trained expertise while minimizing the burden of travel.

- It is important to emphasize that, despite this general preference towards regionalization, there will always be a small proportion of patients (and families) who will favour locally-delivered treatment options. Some of the discussed concerns included added burden of travel, a loss of family and community support due to increased distances, and a potential shift of pre-and post-operative care away from the community. This situation illustrates the importance of support infrastructure, as well as travel distances, in influencing decisions regarding treatment options and where to obtain care.
- Certain institutional level factors were also identified that could hinder the efforts to regionalize surgical care. These include the loss of local expertise, polarization of surgical care structure within a province, difficulties in changing provider behaviour, and complexities associated with developing unanimous guidelines and standards.
- In consideration of aforementioned patient and system-level challenges, it is strongly recommended that policy makers and health care planners be prepared to address various stakeholder perspectives when developing policies for implementing regionalization of complex cancer surgical services.

Strengths

- The best available research evidence was paired with a robust deliberative process that provided a voice to the real-world views and experiences of a diverse group of citizens.
- Panel deliberations identified of a set of core values, and a comparison of three options (ranging from quality-improvement strategies to structural changes) that can guide the efforts of health-system leaders in improving the delivery of complex cancer surgeries.
- Convening the citizen panels in three provinces allowed an examination of views and experiences of citizens residing in provinces with different degrees of consolidation for complex cancer surgeries and access to surgical centres of excellence.

Limitations

- The first limitation of our qualitative analysis is that the findings remain exploratory in nature. They are drawn from a small number of sites, which may not reflect the views and experiences of citizens across all Canadian jurisdictions.
- The second limitation is related to the challenges of engaging citizens in in-depth deliberations over a short period of time. This requires intense efforts from panel members to learn from the evidence and from others' views and experiences, and share their newly informed views about the issue and how to address it. We addressed this limitation to some extent by not aiming for consensus among panel members, but instead to gather a range of perspectives on the topic.

Implications for policy

- Regionalization policies were generally supported by citizens in the sampled jurisdictions. While they were more concerned with ensuring that they received the highest quality of care possible despite a potential restriction of local care, the citizens preferred the provision of local services when possible. Therefore, policies should be implemented with an eye for integrating care pathways that utilize local pre- and post-operative care where appropriate and/or high-quality telemedicine systems to increase access to care.

6.1 OBJECTIVES

Quality-improvement strategies that focus on the process of care and structural changes to health systems may have important implications for the experiences of patients and their families. One approach to explore such issues is to convene a citizen panel bringing together 10-14 citizens from all walks of life. Panel members, informed by a pre-circulated citizen brief, share their ideas and experiences on an issue, and learn from research evidence and from the views of others. The deliberations of a citizen panel can reveal new understandings about an issue and spark insights about how it should be addressed.

To foster such efforts, the McMaster Health Forum (www.mcmasterhealthforum.org) convened a citizen panel in each of three Canadian jurisdictions to deliberate about how to improve the delivery of complex cancer surgeries. In this section, we highlight the views and experiences of panel members about the problem, three options (among many) to address the problem, and barriers and facilitators to implementing the options. In particular, we examined areas of common ground and differences of opinions among panel members and (where possible) identify the values underlying different positions. The study protocol was approved by the Hamilton Integrated Research Ethics Board at McMaster University and all panel members provided voluntary, informed consent. Further details on participant recruitment are presented in Appendix 6.

The main objective of this section is to provide insights into the citizen's preferences in organization of cancer surgical care, along with the debate addressing the potential challenges in access to quality care. This information can inform policymakers and health care administrators regarding citizen's perspective on access to care, travel challenges, and potential approaches to improve quality of cancer surgical care. The features of the problem and a summary of the factors contributing to the problem are outlined in Appendix 7, as well as the three options are summarized in Appendix 8.

6.2 DATA COLLECTION AND ANALYSIS

An overarching qualitative approach was used to synthesize the key themes that emerged from the face-to-face deliberations. This approach was combined with pre- and post-event questionnaires to document participants' views regarding different facets of the problem, as well as three proposed options) to improve the delivery of complex cancer surgeries. The deliberations were recorded and non-participant observers took extensive notes. The recordings and notes were used to draft summaries for each panel that highlighted the views and experiences of panel members, along with values-related themes that emerged during the deliberations. Pre- and post-meeting questionnaires were developed by the research team to assess the relative importance, assigned by panel members before and after the deliberations, to the three options for addressing the problem of shortfalls with the delivery of complex cancer surgeries in Canada. Questions were also included about

participants' preferred location for undergoing complex cancer surgery, the importance of travel distance to their decision to have the surgery or not, and concerns about having to travel a long distance to undergo complex cancer surgery. Descriptive statistics were used to analyze the data collected from the questionnaires. The participant profiles are summarized in Appendix 9.

6.3 MAIN FINDINGS

The summary of the key themes that emerged during the deliberations of the three citizen panels are presented below, with a specific focus on their views and experiences regarding: 1) the problem; 2) three potentially viable options (among many) to address the problem; and 3) the implementation considerations. The section concludes with an examination of results from the pre- and post-questionnaires.

The problem – why is it challenging to improve the delivery of complex cancer surgeries?

All three panels discussed at great length the challenges of making an informed decision in the midst of a cancer diagnosis. The panel members highlighted six key challenges with some consistency, which represented deeper reflections on the features of the problem presented in the brief based on their experiences and values (see Table 6.1 below).

TABLE 6.1: KEY FEATURES OF THE PROBLEM OF DELIVERING COMPLEX CANCER SURGERIES (AND ITS CAUSES) ACCORDING TO PANEL MEMBERS

Panel members highlighted six key challenges with some consistency:

1. Making decisions in the midst of a cancer diagnosis is difficult;
2. Inequities exist in access to optimal surgical care, as well as palliative care and system-level support;
3. Patients and their informal/family caregivers lack support;
4. The cancer patient journey is marked by care coordination problems (e.g., communication breakdowns with and between healthcare providers, and out-of-province care processes being complex and not optimally coordinated);
5. Current financial arrangements (i.e., global budgets for hospitals) limit our capacity to improve the delivery of complex cancer surgeries; and
6. Governance arrangements (e.g., lack of regulation for hospitals and surgeons, and lack of arrangements to optimally address cross-jurisdictional issues) limit our capacity to improve the delivery of complex cancer surgeries.

1) It is difficult to make an informed decision in the midst of a cancer diagnosis

Participants generally agreed that a cancer diagnosis triggers very emotional reactions, which affect the capacity of patients and families to make decisions. They also pointed out the rapid pace at which decisions must be made, often without complete information (e.g., information about their condition, the full scope of treatment options, and the availability of

high-quality surgical and post-operative care) and without the support needed to make these decisions, which nurtured uncertainty about which course of action to take. As one Ontario panel member said: **"[you must make] rushed decisions that could mean life and death."** Participants also emphasized that such decisions are made more challenging for patients and families from rural and remote areas (as well as those from provinces where such surgeries are not performed) because they have to weigh the significant emotional, financial and practical implications of traveling far away from home to undergo lengthy and complex surgical procedures against the potential benefits.

2) Inequities exist in access to optimal surgical care, palliative care, and other system-level support

All three panels discussed inequities of access to optimal surgical care, and in some instances inequities of access to palliative care, and other system-level support. Several participants from the Ontario and Alberta panels acknowledged that they were lucky to live near a regional centre of excellence for cancer (in Hamilton or Edmonton), but they also agreed that many people living in rural and remote areas could face very difficult decisions. Some examples included decision regarding whether to choose a treatment option offered at a hospital close to home (and potentially undergoing surgery in a local, low-volume hospital), or travelling far away from home to receive the surgery at a high-volume hospital with a concentration of expertise (with the hope of better outcomes). A few participants pointed out that these inequities had been an ongoing issue given the vast Canadian landscape and its low-density population, which require that many patients travel to obtain specialized care only available in urban centres. However, they emphasized that it was essential to collectively find ways to overcome all the barriers that may restrict access to care and to alleviate the burden on patients and families who must travel.

3) Patients and their informal/family caregivers lack support

Several panel members indicated that patients and their informal/family caregivers lack support. They emphasized the crucial role that caregivers play along the cancer journey. As one panel member from Alberta indicated: **"It is a daunting journey. If I didn't have people helping me, I would say forget it [undergoing complex cancer surgery]."** A second panel member from Alberta emphasized that: **"As Canadians, we deserve the right to have the proper support system in place when going through cancer."** This issue was also discussed at great length among PEI panel members. Given the need to travel long distances for specialist care, and the lack of supports on the island for both pre- and post-operative care, several panel members noted that it was the informal caregivers who played the most significant support role. Yet, many informal and family caregivers faced many challenges in their roles, particularly those with lower incomes and those living in remote and northern communities who must travel to urban centres to accompany their loved ones undergoing complex cancer surgeries. Participants from all three panels called for greater

financial support to alleviate the burden on caregivers, who can face significant out-of-pocket expenses, as well as greater practical support, including accommodations like the Ronald McDonald Houses that provide a 'home away from home.'

4) The cancer patient journey is marked by care coordination problems

Several panel members emphasized that the cancer patient journey is marked by care coordination problems. For instance, a few Ontario panel members experienced difficult interactions with their family physicians and specialists about their initial symptoms, which may have delayed their cancer diagnosis. Other Ontario panel members provided examples of communication lapses between the regional cancer centre and their local Community Care Access Centre (i.e., local agencies that have responsibility for connecting people with the care they need at home and in their communities), which affected the coordination of post-operative care. As one Ontario panel member indicated: **"When patients leave the hospital, there is a risk of getting into a void."** Such coordination problems were particularly salient among PEI panel members, who highlighted that having to travel out-of-province to undergo complex cancer surgery can complicate the process of care, which is then often poorly coordinated. In addition, they emphasized that that most residents of PEI were **"blind to the way the system works [on the island]."** Thus, they face challenges in getting information related to how the system works, their likely care pathway, and the supports available to them.

5) Current financial arrangements may limit our capacity to improve the delivery of complex cancer surgeries

All three panels talked to a lesser extent about how current financial arrangements may limit our capacity to improve the delivery of complex cancer surgeries. While some participants were generally concerned about the rising costs associated with cancer care and the overall financial sustainability of the health system, others expressed concern that the predominant funding model for hospitals (i.e., global budgets) may not create incentives for hospitals to improve the delivery of complex cancer surgeries, or to increase surgical volumes for certain complex cancer surgeries. PEI panel members were particularly worried that global hospital budgets may create disincentives for providers in other provinces to take on patients requiring complex cancer surgeries from their province, as they could be more expensive to treat.

6) Existing governance arrangements may limit our capacity to improve the delivery of complex cancer surgeries

All three panels also talked (albeit to a lesser extent) about how current governance arrangements may limit our capacity to improve the delivery of complex cancer surgeries. Ontario and Alberta panel members both expressed concern about the minimal regulation regarding which procedures surgeons can perform within their specialty area, or how

frequently they need to perform these procedures to ensure their surgical skills remain up to date. They were similarly concerned about the lack of regulation about which surgical procedures hospitals can perform or how frequently they need to perform them to ensure that quality remains high. One panel member from Alberta indicated that there was a need to raise public awareness about this. **"That scares me. It is very scary and Canadians need to pay attention to that."** Other participants were also concerned that 'solo' surgeons could be allowed to perform these high-risk and resource-intensive cancer surgeries in low-volume hospitals. PEI panel members focused, for instance, on the absence of explicit mechanisms to ensure that the patients referred out of province receive the highest quality care possible in a timely way. PEI panel members also argued that one of the main issues underpinning these challenges was the complex political context. In particular, the dynamics of Canada's federalist structure of government and interprovincial politics were thought to complicate the situation, blurring lines of accountability and making it challenging to pursue changes to the status quo in a consolidated and coordinated way.

Participants were asked to rank each of the options based on preferences after considering their personal beliefs and values. Figure 6.1 summarizes the values associated with each of the options. Regionalizing complex cancer surgeries into designated surgical centres of excellence was ranked number one by a vast majority of participants in all three panels, both before and after the deliberations. This number one ranking increased consistently across all three panels over the pre- and post-panel period, which indicates that as participants learned more about regionalization, their strength of preference increased as a result. The implementation of province-wide quality improvement initiatives to improve the delivery of complex cancer surgeries where they are now being provided was most often ranked second in the Ontario and Edmonton panels (both before and after deliberations), but PEI participants ranked this option third before the deliberations and then second after the deliberations. Lastly, the concept of encouraging the local adoption of quality improvement initiatives in order to improve the delivery of complex cancer surgeries where they are now being provided was most often ranked third in the Ontario and Edmonton panels (both before and after deliberations), but PEI participants ranked this option second before the deliberations and then third after the deliberations. It is quite likely that this decrease in the strength of preference for this option is as a result of the education process facilitated by the deliberations.

The options – how can we address the problem?

After discussing the challenges that reflect or contribute to shortfalls in the delivery of complex cancer surgeries in Canada, participants discussed three options (among many) for making improvements (see Appendix 8 for a detailed description of each option). In this section, we briefly describe the views of panel members regarding each option and (where

possible) identify the values underlying different positions. Table 6.2 presents a summary of the value-related themes that emerged for each option.

Option 1 - Encourage the local adoption of quality-improvement initiatives to improve the delivery of complex cancer surgeries where they are now being provided

While participants from all three panels acknowledged that this option was aimed to continuously improve the local delivery of complex cancer surgeries, and potentially local care processes, most of them agreed that the inherent challenges and drawbacks associated with this option made it the least promising among the three considered to improve the delivery of complex cancer surgeries. When discussing the limitations of option 1, three values-related themes emerged with some consistency:

- **Stewardship** - All three panels indicated that this option may lack the clear direction and incentives needed to implement quality-improvement initiatives. Most panel members saw this option as a 'weak' approach to improving the delivery of complex cancer surgeries. As a panel member from Ontario illustrated: **"It's like telling a child, 'please be good'."** A panel member from Edmonton emphasized that without proper stewardship, local quality-improvement initiatives will be **"moving targets that could be easily side-tracked."**
- **Policies based on data and evidence** - The Alberta and Ontario panels pointed out that this option may lead to policies that are not aligned with what is known about the relationship between surgical volumes and outcomes. An Ontario panel member indicated that trying to provide full access to these complex cancer surgeries in all hospitals was impossible. **"Full access and fairness, it's a utopia. Until we reach population density allowing that, [it will not be possible]."**
- **Excellent health outcomes** - The Alberta and Ontario panels suggested that this option may improve the local delivery of care, but not necessarily improve patient outcomes. Ontario panel members emphasized the lack of available expertise for these complex cancer surgeries. As one panel member pointed out: **"There is a lack of expertise to go around."** Thus, implementing this option does not solve the problem of not having enough surgeons and health care providers available to achieve excellent health outcomes in all hospitals.

A few other values-related themes emerged in some panels that may explain the reluctance of participants to support this option:

- **Choice** - The Ontario panel pointed out that while this option may allow patients to choose local treatment options, it may not allow them to choose the most optimal treatment option (i.e., going to a high-volume hospital).

- **Cost-effectiveness** - The Ontario panel indicated that this option may not make the best use of the limited financial resources and expertise available.
- **Collaboration** - The Ontario panel highlighted that this option, by focusing efforts on local hospitals, may increase fragmentation within the system.
- **Sustainability** - The PEI panel emphasized that there may be a lack the resources in small provinces like theirs to implement and sustain locally driven quality-improvement initiatives.

Option 2 - Implement province-wide quality-improvement initiatives to improve the delivery of complex cancer surgeries where they are now being provided

Participants in all three panels generally agreed that this option was preferred to the previous one, although significant challenges still existed. Several values-related themes highlighted the potential benefits of province-wide quality-improvement initiatives, which include but are not limited to:

- **Continuously improve** - This option may support province-wide continuous-improvement efforts, facilitate the dissemination and uptake of successful local initiatives across the province, but also facilitate patient coordination across jurisdictions.
- **Stewardship** - This may provide the necessary direction and incentives to implement these local quality-improvement initiatives.
- **Accountability** - This option may increase public accountability by requiring public reporting of surgeons' and hospitals' performance, and establishing clear provincial benchmarks.
- **Fairness** - This option may standardize the quality of care across the province, and could be extended to include the development of pan-Canadian guidelines and standards to ensure that all Canadians have access to optimal surgical care.
- **Excellent patient and family experience** – This option may ensure that care pathways are more attuned to the needs of patients and families who must travel outside the province to undergo surgery.

However, when discussing the limitations of this option, two values-related themes emerged with some consistency:

- **Fairness** - Some elements of this option, more specifically implementing pay-for-performance for hospitals and establishing requirements for reporting to the public about quality indicators and other performance measures, may have some unintended consequences. Several participants expressed concerns that such quality-improvement initiatives could lead providers and hospitals to 'cherry-pick' patients who may help them score well, or to avoid those who may cause them to

score poorly, in order to make their statistics look better. As one panel member from Alberta said**: "I have concerns that [they wouldn't] want to take people like me because the success rate is not there. My chances of my survival are not high."**

- **Excellent health outcomes** - By not making structural changes, the impact of this option would most likely be limited in improving patient outcomes.

Option 3 – Regionalize complex cancer surgeries into designated surgical centres of excellence

Overall, this option generally resonated the most with participants in all three panels and was identified as the one more likely to significantly improve the delivery of complex cancer surgeries. Several values-related themes highlighted the potential benefits of regionalization, which include but are not limited to:

- **Continuously improve** - This option may yield continuous improvements in the quality of both surgical and post-operative care.
- **Excellent health outcomes** - This option is more likely to improve patient outcomes.
- **Policies based on data and evidence** - This option may lead to policies that are aligned with what is known about the relationship between surgical volumes and outcomes.
- **Cost-effectiveness** - This option could make, as a panel member from Alberta said, the most **"cost-effective use of trained personnel."**
- **Expertise** - This option may create a concentration of highly skilled surgeons and health care providers to deliver these very complex and high-risk surgical procedures.
- **Safety** - This option may offer safer surgical care by having a critical mass of highly-trained personnel who can support complex cancer surgeries.
- **Innovation** - This option offers an environment more likely to facilitate or trigger innovation.

While regionalization resonated the most with panel members, it still generated some concerns that were embodied in the following values-related themes:

- **Excellent patient- and family-experience** – Regionalizing complex cancer surgeries should not neglect that care must be attuned to the values, needs and preferences of patients and families. As a panel member from Alberta said: **"[regionalization] needs to be looked at in a holistic way, with the family taken into consideration."** In addition, regionalization must be attuned to the unique aspects of different cancer care pathways. PEI panel members highlighted that not all cancers are the same, meaning that regionalization across the full spectrum of care

(pre-operative care to surgical care to post-operative care) should not be considered a 'one-size fits all' approach.

- **Fairness** – Regionalizing complex cancer surgeries should not create additional barriers to accessing optimal surgical care and should include interventions to mitigate the negative consequences of traveling to undergo complex cancer surgery in a regional surgical centre of excellence.
- **Adaptability** – The health system should provide flexible care pathways that allow every patient to receive optimal surgical care in a regional centre of excellence, with the remaining care provided locally.
- **Proximity** – While the regionalization of complex cancer surgeries may be the most optimal way forward, panel members still greatly valued receiving cancer care close to home whenever possible.

These concerns led several panel members to propose *enhancements to the third option*. More specifically, PEI panel members proposed three additional features:

- **Implementing local post-care recovery centres** – PEI panel members emphasized the importance of balancing regionalized surgical care with strong, local post-operative care. These panel members acknowledged that the island (along with other regions across Canada) may not have the capacity to implement surgical centres of excellence, but they proposed the implementation of local post-care recovery centres of excellence.
- **Introducing telemedicine initiatives** – PEI panel members called for effective use of advances in telemedicine or other technologies that enable remote consultations and thus reduce the burden associated with travelling to a regional centre of excellence for routine consultations.
- **Increasing the role of 'patient navigators'** – PEI panel members called for a greater role of 'patient navigators' who can provide support and coordination for patients and their informal/family caregivers throughout the entire care pathway (especially in the context of those who must travel to undergo complex cancer surgery).

Ontario panel members went further and proposed a fourth, stand-alone option: *introducing flexible care pathways, whereby every patient could receive optimal surgical care in a regional centre of excellence, but with the remaining care provided close to home whenever possible.* This option resonated with the proposal from PEI panel members who emphasized the importance of balancing regionalized surgical care with strong, local post-operative care. Indeed, several Ontario panel members were hesitant about the full-blown regionalization of cancer care, especially given the significant burden that it would put on the shoulders of patients and families from rural and remote communities. These participants indicated that regionalization might be a good option for the surgeries, which have a high risk of complications, are resource intensive, and require highly skilled

surgeons and providers. However, they questioned whether all aspects of cancer care needed to be regionalized (e.g., chemotherapy, radiotherapy, and ancillary cancer care) and proposed the development of more flexible care pathways, with the surgery being regionalized, but other cancer care being offered locally whenever possible. This would ensure that patients and families are close to home for as long as possible during the cancer journey, which was perceived as an environment more favourable to recovery.

The implementation considerations- What are concerns with regard to regionalizing care?

After discussing the options for improving the delivery of complex cancer surgeries in Canada, participants examined potential barriers and facilitators for moving forward. These can be classified as either institutional/government level considerations or patient-impact related concerns.

Institutional-level concerns of the implementation of regionalization

In general, five broad groupings of health care system institutional barriers emerged during deliberations:

1. The public resistance to regionalization if it leads to a loss of local expertise or if the regionalization model is based on only the a very limited number of 'poles' (i.e., centres of expertise) in each province
2. The difficulties in changing provider behavior and organizational culture to embrace quality improvement (and the long time required to assess the full impact of these options, which could fuel resistance towards such quality-improvement efforts)
3. The lack of human and financial resources to achieve desired changes in the system (e.g., developing a critical mass of highly skilled surgeons and health care providers to meet the demands for complex cancer surgeries or having the financial resources to implement new and sustainable regional infrastructures)
4. The complexity of developing commonly agreed provincial standards and regional infrastructures, which could face a 'push back' from certain health-system stakeholders
5. The separation of powers between provinces that exists given Canada's federalist structure, which makes it difficult to coordinate health services across jurisdictions (a barrier particularly salient for those living in provinces and territories that are not providing complex cancer surgeries)

When considering potential facilitators for overcoming these barriers and moving forward with implementing regionalization, participants from all three panels emphasized the opportunity of building on positive things already happening in the health system as a foundation for future efforts. In Alberta and Ontario, panel participants highlighted current efforts to regionalize certain complex cancer surgeries and to establish province-wide standards. As for participants in PEI, many acknowledged the reality was that it probably

TABLE 6.2. KEY VALUES-RELATED THEMES THAT EMERGED ABOUT EACH OPTION

	Option 1 - Encourage the local adoption of quality-improvement initiatives to improve the delivery of complex cancer surgeries where they are now being provided	Option 2 - Implement province-wide quality-improvement initiatives to improve the delivery of complex cancer surgeries where they are now being provided	Option 3 - Regionalize complex cancer surgeries into designated surgical centres of excellence
Values-related themes reflecting the strengths of each option	• May allow for **continuous improvement** of LOCAL care delivery	• May allow for **continuous improvement** of care delivery at a PROVINCIAL level via dissemination of successful initiatives and encouraging patient coordination across jurisdictions • May facilitate **stewardship**: Provides leadership and incentivization of locally-based quality improvement initiatives • May increase **public accountability** • May **standardize the quality of care** across the jurisdictions to promote fairness • May ensure **improved patient and family experience** by tailoring care pathways to the needs of the regional users	• May allow for **continuous improvement** of care delivery on PROVINCIAL AND PAN-CANADIAN levels • Most likely option for broadly **improving patient health outcomes** • May facilitate the development of data-driven **evidence-based policies** based on observed changes in outcomes due to higher volumes • May promote more **cost-effective** use of trained personnel • May promote a **concentration of expertise** of highly skilled surgeons and health care providers. This may also increase the **safety** of surgical care given that a critical mass of trained personnel will be assembled. • May facilitate **innovation** through close proximity of expertise
Values-related themes reflecting the limitations of or concerns with each option	• May not lead to better patient outcomes • May not lead to the development of data-driven evidence-based policies since there is no way to observe a possible volume-outcome relationship • May lack stewardship opportunities to provide large-scale leadership and incentivization of locally-based quality improvement initiatives • May reduce patient and family choice to select the most optimal treatment options • May not make the most cost-effective use of the limited financial resources and expertise available • May promote fragmentation and discourage collaboration within the system • May not be a sustainable approach due to limited available resources in smaller provinces to sustain a multitude of initiatives	• May not lead to better patient outcomes • May have unintended consequences, such as hospitals 'cherry-picking' less complex cases thus promoting unequitable access to health care services for patients.	• May reduce the quality of the patient and family experience given that surgical care may be delivered away from home and associated caregiving and community resources • May create a disconnect between the surgical care and locally-based primary physicians and adjuvant oncology treatment: To counteract this, care pathways may be broadened to include pre- and post-operative surgical care closer to home • May create unfair barriers to accessing care due to a need to travel

wasn't feasible to bring complex cancer surgeries to local hospitals in PEI. Given this reality, participants were more accepting of the current situation in which much of this care is regionalized to centres of excellence in other Atlantic provinces. As such, efforts to improve the existing processes of care within and outside of PEI, rather than make major structural changes to the existing system, were seen as possible.

An additional barrier not noted in the deliberations is that of surgeon willingness to adopt new practices or to modify existing ones in order to enact change. Regionalization requires that surgeons accept the evidence that higher volume centres tend to result in better outcomes, and to be willing to change practice patterns in order to benefit their patients. A designated, well-placed opinion leader within the community of practice can champion regionalization policies within a province to minimize the effect of this barrier to change.

Patient-level concerns of the implementation of regionalization

Participants were also asked to consider the impact of regionalization on their personal experience with the health care system when accessing surgical cancer services. They were also asked to consider whether these concerns would then affect their preference for regionalization, although the preference for surgical centres of excellence endured.

1) Travel time

Speaking to the known increase in travel times due to the regionalization of cancer services as demonstrated in the mapping presented earlier in this report, panel members were asked to explore the trade-offs, preferences and concerns associated with travel to undergo complex cancer surgeries through three questions. First, panel members were asked whether they would prefer to undergo complex cancer surgery at a hospital close to their home, even if that hospital did not have a lot of experience performing the type of surgery that they needed (i.e., it was a low-volume hospital) or at a hospital where many of these types of surgeries are performed (i.e., a high-volume hospital), even if that meant they would need to travel far away from home to receive the surgery and for related medical appointments before and after the surgery. The majority of participants in all three panels indicated a preference to have surgery at a high-volume hospital even if that meant they would need to travel far away from home to receive the surgery and for related medical appointments before and after the surgery. On the whole, these views changed very little following the panel deliberations (see Figure 6.1) and resonated with the general tenor of discussions, which emphasized participants' willingness to do everything possible to access a high-volume centre, even if it required travelling to another region.

Although willingness to travel to get the best care possible was a dominant theme, at least one panel participant (from Ontario) viewed the burden to be too great. This person clearly indicated that, whatever the cancer diagnosis and treatment options available, she would

always choose local treatment options and "hope for the best", because she "couldn't put that burden [of travelling to get surgical care]" on her family. Thus, personal and familial circumstances are also important factors that will influence decisions regarding treatment options and where to obtain care. This difference in opinion was stable across the pre- and post-panel questionnaires, suggesting that there will always be a small proportion who will favour local delivery despite downsides.

We also asked panel members how important the distance to travel would be to making the decision to have surgery or not, on a scale of 1 (very unimportant) to 7 (very important). In general, panel members from Ontario and Alberta found that the travel distance was slightly more important than PEI panel members (see Table 6.3). This result likely reflects the reality for PEI residents that they must travel to neighbouring provinces to obtain health care services not available locally. These concerns would manifest more often after regionalization of cancer care services, and should be taken into consideration when making catchment area decisions at the health care planning levels.

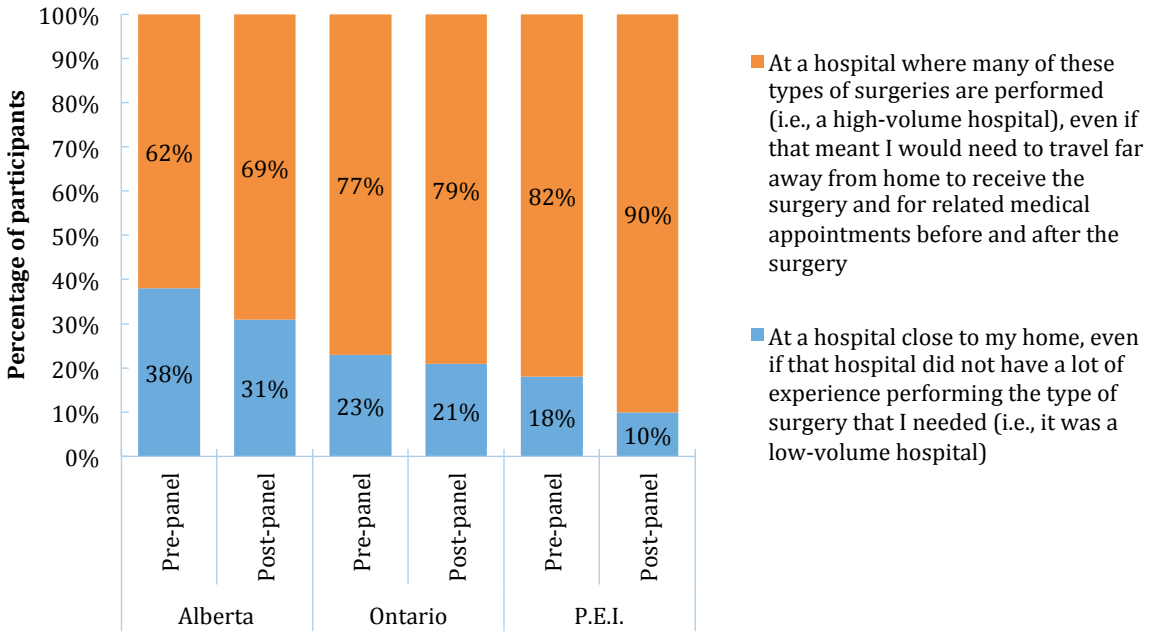


Figure 6.1: Where would you prefer to undergo complex cancer surgery if you needed it?

TABLE 6.3: IF YOU NEEDED COMPLEX CANCER SURGERY, HOW IMPORTANT WOULD THE DISTANCE THAT YOU WOULD HAVE TO TRAVEL BE TO YOUR DECISION TO HAVE THE SURGERY OR NOT?

Panels		Rating on a scale of 1 (very unimportant) to 7 (very important)			
		Mean	SD	Median	Range
Ontario	Pre-panel	4.1	2.2	4.5	1-7
	Post-panel	4.4	2.4	5	2-7
Alberta	Pre-panel	4	2.1	4	1-7
	Post-panel	3.8	2.0	4.5	1-7
PEI	Pre-panel	3.2	1.3	3	2-5
	Post-panel	3	1.6	3	1-6

2) Lack of Local Access to Post-operative Care

Lastly, we asked panel members to identify the two things that concerned them most about having to travel a long distance to undergo complex cancer surgery. Being able to receive good post-operative care once they go back home emerged as the most important concerns in all three panels (both pre- and post-deliberations in Ontario and Alberta, and post-deliberations in PEI). Other sources of concerns that emerged include being able to cover travel costs, being away from family and friends and safety concerns (see Figure 6.2).

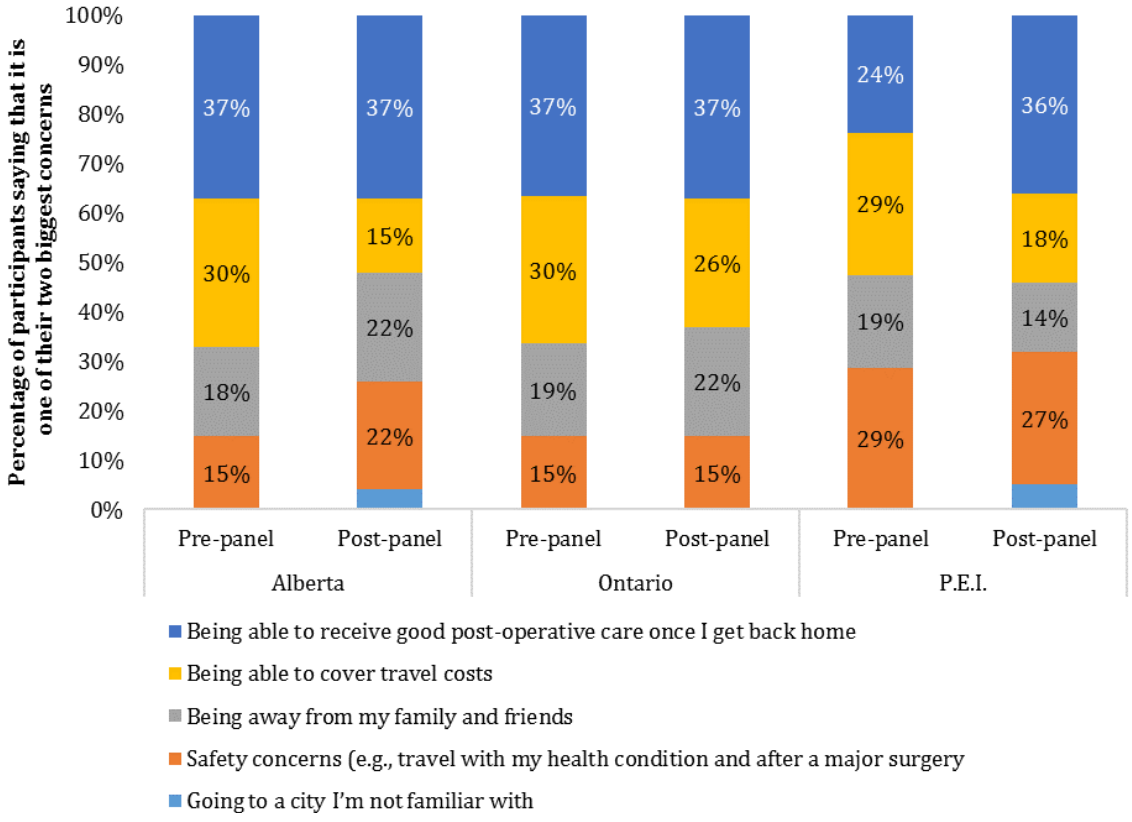


Figure 6.2: What are two things that would concern you the most about having to travel a long distance to undergo complex cancer surgery?

Implications for policy

Despite slight variances across citizen panels, a set of core values was identified that should be considered in improving the delivery of complex cancer surgeries. Several of these values clearly suggest that any quality-improvement initiative or structural change should pay close attention to its impact on patients and families. Indeed, panel deliberations indicated that interventions must be put in place to provide enhanced support for patients and families throughout their cancer journey, and especially to overcome barriers to access optimal surgical care. In addition, participants from all three panels emphasized the opportunity of building on positive things already happening in the health system as a foundation for future efforts, including current efforts to regionalize certain complex cancer surgeries and to establish province-wide standards. Panel deliberations also suggest the need to develop governance arrangements that are favourable to support coordination across jurisdictions, which are essential to supporting patients and families residing in a province or territory where complex cancer surgeries are not available.

7.0: SUMMARY AND KEY RECOMMENDATIONS

The high burden of disease associated with cancer on both the healthcare system and patients presses the need for novel quality improvement initiatives to improve outcomes of surgical cancer care. This report summarized the pan-Canadian current state of surgical cancer care for high-risk, resource intensive surgery for esophageal, pancreatic, liver, lung and ovarian cancers. The findings observed a significant variability in outcomes between provinces and heterogeneous approaches to healthcare system organization and oversight. There has been very little progress on the implementation of active regionalization nationally, despite evidence indicating that regionalization policies can help create an environment for quality improvement. Lastly, the report established that patients are willing to accept the increased travel time to surgical cancer care and apparent loss of local resources if it means that they can expect improved outcomes. This evidence provides support to the implementation of regionalization on a broader scale. While further study is required, we recommend that provinces consider thoughtfully implementing regionalization policies in ways that best serve the needs of their population and by doing so, improving the overall quality of patient care and health care system efficiency.

Evaluating the present state of regionalization and surgical cancer care outcomes is challenging. The impacts of regionalization will be different for each surgery type, due partially to the difference in associated risks and frequency of procedures. Some cancers are diagnosed later in life and the proportion of resectable cases is low. Since there are no prospective disease-specific registries in Canada to date, the breadth of the available data for review was limited beyond mortality, length of stay, and resection rates. There are a number of 'soft' outcomes of interest such as complications, the number of salvage procedures, rates of readmission that could help inform the quality of surgical cancer care, but we could not measure this given the data limitations in this report. We do expect to see an improvement in such outcomes with regionalization as well. Despite these limitations, the potential impact of regionalization to high volume centres remains evident and the evidence can only be strengthened through the establishment of systematic data collection with formalized reporting along with national, disease-specific standards of care so that one regionalized centre is comparable to another.

While challenges are to be expected with implementing any sort of quality improvement program, establishing a program that requires such considerable coordination between

multiple levels of the health care system, communities and citizens is likely to face barriers along the way. It will require a strong coordinated effort to create a change that considers the consequences and develops innovative approaches that overcome the perceived barriers in order to realize the potential benefits to care for Canadians. This report concludes with a series of recommendations that will assist policy makers, health care planners, opinion leaders within the surgical communities of practice and administrators with working towards the desired future state of active regionalization.

Recommendation #1: Surgical cancer care should be integrated into the overall spectrum of provincial cancer services with the capacity for establishing systematic evaluation and the provision of sufficient resources to enact change

A common theme noted during the provincial expert interviews was that there is a distinct lack of leadership for surgical cancer services. In medical and radiation oncology, there is often an appointed Lead who is responsible for directing the implementation of clinical guidelines, manpower allocation, advocacy at policymaker and budget allocation tables and finally the ability to facilitate quality assurance initiatives. In most provinces, there is no such role for the surgical portion of the cancer treatment process, despite the fact that surgery is associated with better survival. The role should be created and filled by a key opinion leader within the surgical cancer community in each province, with a clearly defined mandate and objectives. This common role across the provinces will allow provinces to have the flexibility to integrate this position into their existing cancer care organization schemes while still maintaining the central purpose of the role.

Recommendation #2: Purposeful regionalization of cancer surgical services above and beyond simple consolidation is necessary to improve health care quality and patient outcomes

The intent of this recommendation is to facilitate a formal leadership position in each province that will allow initiatives such as regionalization, quality improvement reporting and the development and uptake of clinical guidelines to gain traction and proceed to implementation. It is important to differentiate between passive consolidation of health care services to centralized locations and active regionalization approaches that encompass a range of quality improvement initiatives in addition to amassing larger volumes. The quantitative analysis undertaken in this report indicates that higher volume centres are associated with improvements in patient mortality rates after resections, yet volume alone is not wholly responsible for these improvements. Even in the highest volume centres, the introduction of evidence-based surgical standards and clinical pathways, the utilization of dedicated, trained staff training or the adoption of optimal

surgical techniques have the potential to further reduce mortality. Regionalized, higher-volume centres are more likely to possess the infrastructure and manpower to provide multidisciplinary care, a key quality standard indicated by clinical guidelines released by organizations such as the American National Comprehensive Cancer Network (NCCN)[167,168] and the European Society for Medical Oncology (ESMO)[169,170] for thoracic malignancies and by NCCN for hepatobiliarypancreatic cancers[171.172]. Lastly, feedback obtained via the citizen panel work undertaken for this report indicated that the public is willing to trade off a certain degree of convenience for optimal outcomes. This provides the justification needed on a user-basis to support the regionalization of surgical cancer services.

The intent of this recommendation is promote the adoption of active regionalization on a provincial basis, as it has shown promise as a good approach to improve the quality of surgical cancer services that is also palatable to patients and the general public.

Recommendation #3: Regionalization policies should be tailored to meet unique provincial needs

During the course of consultations with experts across the country, it was very clear that each province has unique needs that will impact the implementation of quality improvement policies within existing health care system organization. Each province possesses different healthcare system governance and oversight structures, geographic realities, and access to care expectations that shape how policies can be implemented. This is best demonstrated by the case of Prince Edward Island, where complex surgeries are often referred to neighbouring provinces. This policy certainly limits access to care, but the low population of this province means that meaningful volumes could never be met. In order for residents of PEI to realize the benefit of regionalization policies, this population would be best suited to continue to be referred to other provinces for complex care. Since no one province shares similar infrastructure with another, it is not feasible to establish a single, national regionalization policy. Regardless, the volume-outcome effect should be considered when allocating surgical centres of excellence where appropriate. Similarly, while it would be ideal to be able to define a threshold for each cancer type to be incorporated into provincial regionalization policies, the relative difference in provincial populations means that it would be truly impractical to recommend a single volume cut-off.

The intent of this recommendation is not enforce a single, national policy for regionalization activities, but to instead acknowledge that each province should integrate this policy into their current organizational infrastructure. Each province should be responsible for initiating a dialogue within each community of practice, led by the Surgical

Cancer Care Lead, to establish provincial needs and to define reasonable volume standards that consider population distribution and available resources.

Recommendation #4: Surgical cancer care should embrace flexible implementation of regionalization policies based on access to care concerns and patient preferences

A primary concern of patients contemplating undergoing surgical cancer care in regionalized centres of excellence is that some patients would be removed from their communities and support networks and would face longer travel times to access care. Over the course of the citizen panel discussions, participants indicated that innovative healthcare delivery approaches can help overcome the burden of reduced access to care that may come with adopting regionalization policies. These approaches can take the form of the development of collaborations with local institutions in smaller centres with oversight and direction from the regional centre, where patients can attend for diagnostic assessment programs, clinical testing or post-surgical examinations closer to home while still realizing the benefits of regionalized care. Alternately, telemedicine may be utilized, where patients can present at their local healthcare facility for a consultation with their surgeon and care team at the regional centre. The objective of these adapted approaches would be to allow patients to minimize costs and travel while still receiving high quality care.

The intent of this recommendation is to encourage provinces considering the implementation of regionalization to seek innovative approaches that will allow patients to see the benefits of such quality improvement programs while also ameliorating the impact on patients and their families. This flexibility is intended to promote implementation given the different provincial realities.

Recommendation #5: Nationally-implemented standards of care should be developed for each cancer surgery type

The volume-outcome relationship has a significant impact on patient mortality and likely other less concrete outcomes, but does not account for all the improvements in outcomes. Regionalized centres will naturally have a higher volume of patients than they would have in a non-regionalized setting, but there are other quality factors such as highly trained personnel, the creation of specialized surgical stepdown units or the hiring of sufficiently trained surgeons among many other possibilities. One such approach to ensuring a degree of uniformity as to what defines a regionalized centre would be to develop nationally-implemented standards of care specific to each cancer type. Each specialty-based

community of practice should be charged with defining minimal standards for practitioner certification or training to ensure only highly trained surgeons are undertaking these complex resections, the use of multi-disciplinary cancer conferences to ensure the most appropriate care is selected for patients, the establishment of minimal institutional and/or surgeon case volumes to guide policy decision making, and the mandatory participation of centres in national quality improvement registries to facilitate the evaluation of regionalization efforts. The standards should also consider the integration of specialized nursing, critical care and anaesthesia services, and adequate radiology and pathology service support to ensure that the appropriate personnel and infrastructure are in place to deliver care according to clinical guidelines. These standards need to be evidence-based using current research, similar to those that have been developed internationally, to encourage the uptake of best practices on both provincial and national levels. The adoption of standards nationally will also help to address the disparities in patient outcomes noted between the provinces, both by establishing what constitutes quality care, but also by allowing outcomes to be compared between institutions in different provinces to better define success. Without defined national standards of care, there is too much inherent variability in care practices. The evaluation of adherence to these surgical standards of care should be integrated into existing national evaluation structures in order to measure province-level improvements and inter-provincial variance.

The intent of this recommendation is for national-level specialty communities of care to review existing evidence and to undergo a consensus generating exercise to establish suitable informed standards of care centred on regionalizing surgical cancer care services. These standards are then intended to be applied in each province, with regular auditing for compliance and quality improvement.

Recommendation #6: A structured benchmarking process for each specialty should be supported to improve surgical outcomes and inform policy decisions

When specialty-based communities of care are asked to establish nationally-defined standards of care, it is expected that standardized data collection with explicit public reporting will be a key component to measure the impact of regionalization policies. As per the defined standards of care, all surgical care providers should be expected to participate in these national disease-specific registries. The utilization of registries with formal reporting procedures can improve the quality of patient care independently of other interventions, as observed with the American College of Surgeons' National Surgical Quality Improvement Program (NSQIP). This program utilizes systematic data collection and reporting for patients undergoing surgery for any indication, and has reported reduced mortality and morbidity variability by 9% and 30%, respectively[173]. While there is apparent value to generic databases, considerably more valuable information can be

derived from disease-specific registries that capture a standardized core dataset consisting of patient demographics and risk factors, cancer and procedure-specific details and eventual outcomes, including surgery-related adverse events and oncologic outcomes. The richness of this data will allow for a valid evaluation of improvements in patient outcomes and reductions in inter-provincial variability as a result of volume intensification and the establishment of standards of care.

It is necessary for each community of practice to define and standardize these data fields to ensure that data collection is clinically relevant and that the results can be compared between institutions. The standardization of data collection across sites will allow surgeons and institutions to be benchmarked against their peers with trends tracked overtime both within and between participants. This continuous monitoring facilitates the detection of poor outcomes, informing decision makers and health care planners of areas requiring additional attention or resources. Such monitoring also has the potential to allow for the creation and dissemination of best practices, where institutions with excellent outcomes can share innovative strategies with other institutions, resulting in a system-wide improvement in outcomes according to the principles of positive deviance. Finally, the collection and monitoring of surgical data encourages surgeon accountability to evidence-based guidelines and the established standards of care.

The recommendations of this report were selected as they indicate important factors that are missing in the present state of surgical cancer care across Canada, leading to large gaps in knowledge and inconsistencies in surgical cancer care delivery. Provinces implementing active regionalization should consider these recommendations starting from the policy development stages and continuing through to ongoing evaluation and monitoring. Ideally, adoption of a nationally standardized, provincially implemented approach to regionalization will place Canada as a world leader in quality surgical cancer care for high-risk, complex cancer surgery.

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Appendix 1: Summary of Literature Review

Databases Searched:

- *Medline, Embase, HealthStar, Canadian Health Research Collection*

Inclusion and Exclusion Criteria:

Inclusions

1. Age: Greater than 18 years
2. Study population
    a. Article published after year 2000 for ovarian, lung, pancreatic, esophageal, and hepatobiliary since 1990
3. Outcomes of regionalization practices
4. Volume-outcome relationships (at either a surgeon- or a hospital-level) with any outcome
5. High-volume vs. Low-volume treatment centres
6. Measurable outcomes:
    a. Patient 5-yr survival rate
    b. In-hospital mortality
    c. Total length of hospital stay
    d. Readmission rates
    e. Adverse events
    f. Quality of life
    g. Cost analyses

Exclusions

1. Titles and abstract in foreign languages
2. Unable to locate the journal article
3. Single Institution or single surgeon study
4. Data collected before 1985
5. Study published before 1990

Literature Summary Tables

1) Esophageal Cancer

Table 1a: Surgeon Specific Factors and Patient Outcomes, Esophageal Cancer

Ref #	Type of Resection	Specialty	Volume Categories (per year)	Total No. of surgeons over study period N (%)	Total No. of patients over study period N (%)	Mortality (%) [30-day unless otherwise specified]	Morbidity/ Post-operative Complications	Length of Stay (days)	Overall Survival
69	Esophagectomy	NR NR	HV: >6 MV: 2-6 LV: <2			9.2[S] 13.1 18.8	NR NR	NR NR	NR NR
74	Esophagectomy	NR NR	HV: NR LV: NR			Lower[S] Higher	NR NR	NR NR	Longer[S] Shorter
41	Cardioesophageal	NR NR	HV: >12 MV: 4-11 LV: <4		1125	11.8 6.6[S] 15.1	NR NR	NR NR	~18% (ns difference) (12-15 mos)
75	Esophagectomy	NR NR	HV: ≥6 LV: ≤5			0[S] 22.0	NR NR	NR NR	NR NR
63	Esophagectomy, Cardia Cancer Resection		HV: >5 LV: <5		275	2% 7%	-# patients with at least 1 complication: 42% vs. 49% -# patients with at least 2 complications: 18% vs. 24% -Risk of Anastomotic leakage: ~8 fold more for LV vs. HV[S]	NR	NR
129	Esophagectomy	607	HV:>6 MV:2-6 LV: <2			2.6 2.1% 7.1%			
130	Esophagectomy	195	HV: >6 LV: <6			16.9 4.2			
45	Esophagectomy		LV: quartiles 1-2 MV: quartile 3 HV: quartile 4	NR	1335	NR	NR	NR	LV: reference MV:0.82 (0.70 to 0.97) HV:0.85 (0.68 to 1.06)
131	Esophagectomy	NR	Cases/surgeon Surgeon 1: 38 Surgeon2: 36 Surgeon 3: 16	5	252	S1: 5.2 S2:2.7% S3: 0% S4: 5.4%	S1: 23.7% S2:22.2% S3: 50% S4:18.9%	NR	Mean survival (months): S1:40 S2:31

			Surgeon 4: 74 Surgeon 5: 88			S5: 4.5%	S5:20.4%		S3:22 S4:30 S5:31
76	Esophagectomy, Gastric Cardia	NR	LV:<10/yr HV:≥10/yr	NR	232	HV: 0 LV: 2%	NR	HV: 18 (9–58) LV: 18 (7–102)	NR
132	Esophagectomy	NR	LV: 2 MV:2-6 HV:>6	NR	615	NR	HV: reference MV: 0.80 (95% CI: 0.45–1.42) LV: 0.99 (95% CI: 0.49 –1.98)	NR	NR
133	Esophagectomy	Cardio thoracic General	HV: >100 LV: ≤100	NR	9034	6.1% 9.0% LV only: CardioThoracic: 6.8 (4.3-9.4) General: 9.8 (9.0-10.6) HV only: Cardio Thoracic: 5.9 (4.9-7.0) General: 6.7 (5.5-7.9)	NR	NR	NR

Table 1b: Hospital-Specific Factors and Patient Outcomes, Esophageal Cancer

Study	Type of Resection	Total No. of Hospitals	No. of Patients	Volume Categories (per year)	Mortality [in-hospital] (%)	Morbidity/Post-operative Complications	Length of Stay (days)	Overall Survival (5-year)
93	Esophagectomy	104	4939	>20 10-20 <10	OR: 0.49[S] OR: 1.01 reference	NR NR	NR NR	NR NR
74	Esophageal Resection	NR NR		High Low	Lower Higher	NR NR	NR NR	NR NR
41	Esophagectomy		1125	≥20 <20	10.2% 9.8%			~18% (13 months for both groups)*+
112	Esophagectomy	47	613	>8.8 <8.8	10.9% 15.6%	NR NR	NR NR	NR NR
113	Esophagectomy	40 603		>9.0 <4.0	6.5%[S] 15.0%	NR NR	NR NR	NR NR
134	Esophagectomy	NR NR		≥10 <3	Lower[S] Higher	NR NR	NR NR	NR NR

61	Esophagectomy	NR NR		>6 ≤6	NR NR	39%[S] 48%	NR NR	NR NR
135	Esophagectomy	6 138		>16 <3	3.7%[S] 11.8%	NR NR	20% (>20 days) 28% (>20 days)	NR NR
62	Esophagectomy	204 162		>8.5 <8.5	2.5%[S] 15.4%	Less in High Volume Hospitals Post-op mortality for patient with one complication: 16.9% vs 2.5%[S] for those without complications	NR NR	NR NR
34	Esophagectomy	31 618		>19 <2	8.1%[S] 23.1%	NR NR	NR NR	NR NR
34	Esophagectomy	79 944		>19 <2	10.6%[S] 17.0%	NR NR	NR NR	NR NR
136	Esophagectomy	3 61		28 1.1	2.5%[S] 9.2%	NR NR	13 days 15 days	NR NR
137	Esophagectomy	757 928		>20 ≤10	4.9%[S] 12.1%	NR NR	NR NR	NR NR
138	Esophagectomy	3 39	1136	>15 4-15 ≤3	2.7%[S] 12.7% 16.0%	NR	11[S] (9-16) 20 (13-31) 19 (12-33)	NR NR
139	Esophagectomy	101 in-total	340	≥5 <5	Early post-op: 3.0%[S] 12.2%	Complications: 55% 68%	14.7 days[S] 17.7 days	NR NR
36	Esophagectomy	NR NR		≥11 ≤ 5	3.4%[S] 17.3%	NR NR	NR NR	NR NR
140	Esophagectomy	5 196		>30 ≤5	6% 17%	NR NR	22 days 22 days	NR NR
42	Esophagectomy		1199	>10 <10	4.5% 9.3%	NR NR	NR NR	27.4%*+ 23.8%
118	Esophagectomy	206	822	14.7-107				33.7% S* 17.4%
43	Esophagectomy		1302	>35 20-34 13-19 13				36.8%* 37.6% 38.5% 43.4%
44	Esophagectomy		213	>20 <20				41.7% 22.3%
45	Esophagectomy	NR	1335	LV: quartiles 1-2 MV: quartile 3 HV: quartile 4	NR	NR	NR	LV: reference MV: 1.03 (0.87 to 1.22) HV: 0.93 (0.77 to 1.13)

119	Esophagectomy	46 (pre regionalization) 15(post regionalization)	NR	Pre regionalization vs. post regionalization	Esophagectomy 5.9% to 5.8%	NR	NR	NR
141	Esophagectomy Gastrectomy	NR	19864	Annual hospital volume: 1-10 11-20 21-30 31-40 ≥41	Esophagectomy: 1-10:reference 11-20: 0.82 (0·61, 1·11) 21-30:0.68 (0·50, 0·93) 31-40:0.58 (0·39, 0·85) 41+:0.55 (0·42, 0·72) Gastrectomy 1-10: reference 11-20: 0·84 (0·67, 1·05) 21-30: 0·64 (0·41, 0·99)	NR	NR	2 year survival: Esophagectomy 1-10: reference 11-20: 0·92 (0·78, 1·08) 21-30: 0·84 (0·63, 1·11) 31-40: 0·77 (0·63, 0·94) 41+: 0·79 (0·66, 0·96) Gastrectomy 1-10: reference 11-20: 1·04 (0·93, 1·15) 21-30: 1·01 (0·84, 1·22)
142	Esophagectomy	217	1210	Divided into quintiles	Q1: 12.82% Q2:13.41% Q3:6.35% Q4: 5.5% Q5: 2.21%	NR	NR	NR
46	Esophagectomy Gastrectomy	NR	24,246	Very low (1–5) Low (6–10) Medium (11–20) High (≥21)	*Six month mortality Esophagectomy Very low: ref Low: 0.90 (0.78–1.03) Medium: 0.78 (0.62–0.97) High: 0.48 (0.38–0.61) Gastrectomy Very low: ref Low: 0.95 (0.84–1.07) Medium: 0. 95 (0.83–1.08) High: 1.10 0.82–1.49)	NR	NR	3 year survival Esophagectomy Very Low: reference Low: 1.01(0.94–1.10) Medium: 0.90 (0.81–0.99) High: 0.77(0.70–0.85) Gastrectomy Very Low: reference Low: 0.99 (0.91–1.07) Medium: 0.99 (0.90–1.08) High: 0.98 (0.86–1.12)
143	Gastrointestinal operations (Esophagectomy, Gastrectomy)		3870	Cases/year LV:1-10 MV:11-20 HV:21-30 VHV:≥31	NR	Hazard ratio LV: ref MV: 0.974 HV:0.865 VHV:0.660	NR	NR

47	Esophagectomy	NR	321	Esophagectomy between 2000-2006 LV:≤10 MV:11- 20 (inclusive) HV: ≥20	LV: 6.4%, 95%CI 1.7–18.6% MV: 4.3%, 1.6–10.3% HV: 2.6%, 1.0–6.4%	NR	NR	3 year survival rate: LV: 45.1% (23.4–64.6%) MV: 58.0% (46.1–68.2%) HV: 64.4% (CI 53.8–73.2%)
144	Esophagectomy	709	31380	0-4 5-9 10-19 20-39 40-79 80+	0-4: 6% (5.3–6.8) 5-9: 4.7 (4.2–5.3) 10-19: 4.2 (3.7–4.7) 20-39: 3.2 (2.8–3.7) 40-79: 2.2 (1.8–2.6) 80+: 1.8% (1.3–2.3)	NR	NR	NR
133	Esophagectomy	NR	9034	HV: >100 cases LV: ≤ 100 cases	HV: 6.3% LV: 9.6%	NR	NR	NR
76	Esophagectomy, Gastric cardia resection	NR	232	HV:≥10/year LV: <10/year	HV:0% LV: 3%	NR	HV: 19 (9–57) LV: 17.5 (7–102)	NR
145	Esophagectomy	12	903	HV: 1 of the hospitals under study LV: 11 of the hospitals under study	HV: 5%[s] LV: 13% P<0.001	NR	HV: 14 LV:21 (median days) P<0.001	NR
146	Esophagectomy	NR	11838	VLV:≤9 LV:10-19 MV:20-29 HV30-39 VHV: 40+	VLV:11.8% LV:8.3% MV:6.0% HV:9.0% VHV:4.5% *most recent dataset in results	NR	VLV:25.3% LV: 25.3% MV:20.9% HV:25.2% VHV:22.7% *% with "prolonged hospital stay"	NR
147	Esophagectomy, Pancreaticoduodenectomy, Gastric resection	NR	NR	LV:<5 MV:5-20 HV:>20	Esophagectomy LV: 22.2 (12.7–34.5) MV: 3.3 (1.8–7.0) HV: 8.3 (6.2–12.6) Pancreatic-duodectomy LV: 6.3 (0.2–30.2 MV: 7.6 (3.7–13.7) HV: 5.6 (1.6–13.8) Gastric Resection LV: 8.2 (5.0–12.7) MV: 8.0 (4.6–12.2) HV: 8.4 (3.7–15.9)	NR	NR	NR

148	Esophagectomy, Gastric cardia resections	74	1429	LV: <5/year MV:5-15 HV:>15	Hospital mortality LV:10.4% MV:6.3% HV:3.5%	NR	LV: 21 (16-32) MV: 18 (13-26) HV: 18 (15-23)	LV:7% MV: 19% HV:22% (p=0.02)
149	Esophagectomy	111	2801	# done over period LV: <50 MV:50-149 HV:>150	LV:5.6% MV:2.6% HV:1.7%	NR	LV and MV: "more than 25" HV: 20 (median)	NR
150	Esophagogastric (OG) resection	NR	456	Pre vs post centralization (prior and post 2006)	Precentralization: 10.3% Post centralization: 3.6% P=0.006	NR	NR	Median survival Precentralization: 1.1 years Post centralization: 1.5 years
151	Esophagectomy	874	4498	LV:1-6 MV:7-32 HV: 33+	LV: 2.2 (1.3–3.7) MV: 1.6 (1.0–2.5) HV: Reference	NR	NR	NR
47	Esophagectomy	NR	321	LV: ≤10 MV:11-20 HV: >20	LV: 6.4%, (95%CI 1.7–18.6%) MV: 4.3%, (95%CI 1.6–10.3%) HV: 2.6%, 95%CI 1.0–6.4%	LV: 23.4%, (95%CI 12.8–38.4%) MV: 31.0%, (95%CI 23.0–40.3%) HV: 18.7%, (95%CI 13.1–25.9%)	NR	3 year survival LV: 45.1% (95%CI 23.4–64.6%) MV: 58.0% (95%CI 46.1–68.2%) HV: 64.4% (95%CI 53.8–73.2%)

**Overall 5-year Survival. ⁺Tumour stage included in analysis*

Table 1c: Hospital type and Patient Outcomes, Esophageal Cancer

Study	Hospital Type	Type of Resection	Volume Categories (per year)	Total No. of patients over study period	Mortality (%) [30-day unless otherwise specified]	Morbidity/Post-operative complications	Length of stay (days)	Overall Survival (Years)
152	Specialist District	Esophagectomy	NR NR	53 60	5.6% 12.5%	NR NR	NR NR	1-year:63% 1-year-62%
118	NR	Upper gastrointestinal (UGI) resections	Pre -Post regionalization	606	Pre: 2.5% Post: 2.4%	Pre: 40% Post: 45%	Pre: Median 16 (2-72) Post: Median 13 (3-49) P=0.024	NR

153	High volume referral centre, but has low volume of actual operations	Esophagectomy	NR	87	1%	53%	NR	1 year: 89% 3 year: 60%
154	Low volume centre	Esophagogastrectomy	NR	128	1.6%	53.9%	12 (median)	32.4% for adenocarcinoma and 47.7% for squamous cell carcinoma.
155	Low volume centre	Laparoscopic transhiatal esophagectomy	NR	16	0	43.75%	Mean hospital stay was 16.7 days (range, 9 to 30)	NR

2) Pancreatic Cancer

Table 2a: Surgeon Specific Factors and Patient Outcomes, Pancreatic Cancer

Ref #	Type of Resection	Specialty	Volume Categories (per year)	Total No. of surgeons over study period N (%)	Total No. of patients over study period N (%)	Mortality (%) [30-day unless otherwise specified]	Morbidity (%)	Length of stay (days)	Overall Survival
72	Pancreaticoduodenectomy	Pancreatic (training)	HV: >=12 LV:<12	NR	630	3.9 4.3	55.3 65.6	15.5 16.9 (mean)	
15	Pancreatic Head Resection	Pancreatic	LV:<1 MV:1-3 HV:>3	98	350	14[S] 10 3[S]	42[S] 41[S] 25[S]	24[S] 23[S] 18[S]	Pancreatic Ductal Adenocarcinoma LV:12% MV:11% HV: 17% Ampullary adenocarcinoma: LV: 27% MV:36% HV:44%
73	Pancreaticoduodenectomy	NR	1 2 3 4-6 7-9 10-16 ≥17	282	698	6.6 5.4 3.4 10.2 8.7 0.0 2.6	NR	27 19.4 19.7 19.7 19.6 17.6 16.8	NR

*[S=] *Significant difference*

No studies found comparing effects of surgeon specialty on outcomes

Table 2b: Hospital-Specific Factors and Patient Outcomes, Pancreatic Cancer

Ref #	Type of Resection	Total No. of Hospitals	No. of Patients	Volume Categories (per year)	Mortality [30-day] (%)	Morbidity	Length of stay (days)	Overall Survival (5-year)
15	Pancreatic Head Resection	33	350	LV: <5 MV:5-10 HV:>10	LV:13% MV:7% HV:4%	41% 41% 29%	23 23 18 All significant	Pancreatic ductal adenocarcinoma LV:11% MV:14% HV: 15% Ampullary adenocarcinoma: LV: 27% MV:36% HV:44%
12	Pancreaticoduodenectomy	10	158	Between January 1995 and April 2000 (pre-regionalization) Between July 2005 and July 2009 (post regionalization)	24.4% 2.6% (defined as "before discharge to patients home, nursing home, or rehab centre")	82% 38% (Intra and post morbidities combined) P=<0.001	NR	NR
13	"pancreas cancer surgery"	25-38 (Ontario) 24-37 (Quebec)	1895 (1994-2004 in Ontario) 1396 (1994-2004 in Quebec)	HV: >=10/yr LV: <10/yr	10.4->2.2% in Ontario (1994 vs 2004) 7.4, 9.9% Quebec (1994 vs 2004)	17.8, 21.7 % (1994 vs 2004, Ontario) 25.2 vs 39.3 (1994 vs 2004, Quebec)	NR	NR
101	Pancreaticoduodenectomy	221	1576	Low: <=5 Med: 6-13 High:14-51 Very high : 89-104 (only 2 hospitals in region)	Low: 12.4% Med: 7.8% High: 5.9% V. High: 2.6%	NR	NR	NR
64	Pancreatectomy, Pancreaticoduodenectomy	466	3189	HV: >=10 LV: <10	HV:3.3% [S] LV:7.6% (UA)	NR	HV: 12 [S] LV:14 (median)	NR

11	Various pancreatic resections	1743	39463	HV: >18 resections/yr MV:5-18 resections/yr LV: <5 resections/yr	5.9% overall LV: 3.3 MV:2.1 (odds ratio) Pancreactomy: LV:9.2% HV:2.4% PD: LV:8.2% HV:4.8%	NR	NR	NR
103	Pancreatic Resections	68	842	HV: >42 MV:22-42 LV:<22	3.4% 12.8% 14.4% All values significant	NR	32.2 39.9 36.8	NR
104	Pancreaticoduodenectomy	1772	7229	Very LV: 0-.99/yr LV:1-1.99/yr MV:2-4.99/yr HV:5+/yr	(In hospital, 30day) VLV: (16.1%,12.9%) LV: (12.7%,9%) MV: (10.1%, 7.3%) HV (4.1%, 3.0%) P<0.001	NR	VLV:22 LV:21 MV:20 HV:16 P<0.001	NR
14	Various resections	Centralization to 5 major cancer centres during study period	1033	NR	Went from 3.5 to 1.8% during study period	NR	NR	NR
106	Pancreaticoduodenectomy	126	1794	VLV: 1-2/yr LV: 3-5/yr MV: 6-10/yr HV: 11-20/yr VHV: >20/yr	VLV: 11.4% LV: 10.2% MV: 10.7% HV: 5.9% VHV: 5%	NR	Negative association; plateau after 10 PDs/ yr P=0.027	NR
94	Pancreatic resections (various)	1000 (approx.)	8370	HV: avg >20/yr LV: avg <20/yr	HV :3.1% LV : 9.0% P<0.0001	NR	NR	NR
107	Pancreaticoduodenectomy Distal Pancreatectomy Total Pancreatectomy	NR	103,222	<3 3-5 6-11 12-23 24-35	PD: 4.78 Distal pancreatectomy:3.84 Total pancreactomy: 2.60	Pancreaticoduodenectomy >36: 19.76%-48.41% <36:27.74-51.76% distal pancreatectomy	NR	NR

				>36	Odds ratios show higher likelihood of mortality in low volume hospital	>36: 17.78%-36.3% Total pancreatectomy >36:8.06-35.2% <36:28.57-57.26 Ranges are lowest and highest value in category Ranges contain data for all ages, ranges for "<36" contain data for all ages and surgeon volumes up to 36		

3) Liver Cancer

Table 3a. Surgeon Specific Factors and Patient Outcomes, Liver Cancer

Ref #	Type of Resection	Specialty	Volume Categories (per year)	Total No. of surgeons over study period N (%)	Total No. of patients over study period N (%)	Mortality (%) [30-day unless otherwise specified]	Morbidity/ Post-operative Complications	Length of Stay (days)	Overall Survival
48	Liver lobectomy Partial Hepatectomy		HV: ≥96 MV:20-95 LV: ≤19	286 (Mean Volume per surgeon 9.8 operations)	2799				46.8[S] 40.8 33.7 Unadjusted and adjusted significant

*****No studies found comparing effects of surgeon specialty on outcomes***

Table 3b: Hospital-Specific Factors and Patient Outcomes, Liver Cancer

Study	Type of Resection	Total No. of Hospitals	No. of Patients	Volume Categories (per year)	Mortality [30-day] (%) In-hosp	Morbidity/Post-operative Complications	Length of Stay (days)	Overall Survival (5-year)
18	Hepatic Resection	247 (9% high volume)	9919 (75% in high volume)	≥10 1-9	4.6 6.1 (S on univariate analysis, NS at multivariate)		12.1 (1-267) 13.2 (1-188)	

17	Segmentectomy, Lobectomy and Extended lobectomy	855	18 046	VHV: >70 HV: 36-70 LV: 18-35 VLV: <18	0.4% (OR:.16)[S] 1.1% (OR:.52)[S] 1.3%, (OR:.70) 1.6% (OR: ref)	NR	21.5±16.5 20.5±17.2 21.6±17.2 24±20.5[S longer]	NR
48	Liver lobectomy Partial Hepatectomy	90 (Mean Volume: 31.2)	2799	HV: ≥299 MV: 88-298 LV: <87				43.1% 45.1% 34.0% Unadjusted signif greater in HV, adjusted NS
37	Major Hepatic Resections (Hepatectomy)	138	507	>17per 5 yrs ≤16 per 5 yrs	9.4[S+] 15.4-22.7 (risk-adjusted)		11.3 [S+] 13.1-14.3	
20	Hepatic Resections	52	606	>15 ≤15	1.5[S] 7.9	12.7 13.2 (adj outcomes signif better in favor of LV)		
19	Hepatic Resection		16,582	≥10 ≤9	In-hosp: 5.8[S] 8.9			
38	Hepatic Resection	475	2097	≥10 ≤9	3.9[S] 7.6 (OR=.60, S after adjusting for case-mix)		Median 7 (5-9)[S] 8 (5-11) (S after adjusting for case-mix)	

**Overall 5-year Survival. [+]Adjusted for patient characteristics*

Table 3c: Hospital type and Patient Outcomes, Liver Cancer

Study	Hospital Type	Type of Resection	Volume Categories (per year)	Total No. of patients over study period	Mortality (%) [30-day unless otherwise specified]	Morbidity/Post-operative complications	Length of stay (days)	Overall Survival (Years)
31	Community-based teaching hospital with a surgical residency training program	Major Liver Resections (1992-2002)	NR	46 (14 surgeons) 23 by 1 surgeon		(16/46) 34%	9.7	36% (8 of 22 patients) 2 yr: 61% (20 of 33)

4) Lung Cancer

Table 4a: Surgeon Specific Factors and Patient Outcomes, Lung Cancer

Ref #	Type of Resection	Specialty	Volume Categories (per year)	Total No. of surgeons over study period N (%)	Total No. of patients over study period N (%)	Mortality (%) [30-day unless otherwise specified]	Morbidity/ Post-operative Complications	Length of Stay (days)	Overall Survival
111	Lobectomy	Thoracic Cardiothoracic	HV: >47 LV: <15			2.5% 2.7%	NR NR	NR NR	NR NR
69	Lung resections	NR NR	HV: >17 LV: <7			5.0[s] 6.1	NR NR	NR NR	NR NR
70	Lobectomy	NR NR	HV: >31 LV: <22			0.9[s] 2.6	NR NR	NR NR	NR NR
71	Lung resections	NR	LV:≤46 MV:47-131 HV: 132+	377	79	LV: reference MV: 0.43(0.24–0.77) [s] HV: 0.26(0.13–0.53)[s]	NR	NR	NR
78	Lung resections	Thoracic Cardiothoracic General	HV: >20 HV:>20 HV:>20			5.1% 5.2% 6.1%	NR NR NR	NR NR NR	NR NR NR
79	Lung resections	Thoracic Cardiothoracic	HV: ~58 LV: ~22			5.5% 7.7%	NR NR	NR NR	31% 32%
80	Lobectomy Pneumonectomy	Thoracic General Thoracic General	NR NR NR NR			3.0% 5.3% 11.8% 20.2%	NR NR NR NR	11.8 11.6 11.5 14.9	NR NR NR NR

Table 4b: Hospital-Specific Factors and Patient Outcomes, Lung Cancer

Study	Type of Resection	Total No. of Hospitals	No. of Patients	Volume Categories (per year)	Mortality [30-day] (%)	Morbidity/Post-operative Complications	Length of Stay (days)	Overall Survival (5-year)
70	Lobectomy	15 134		<168 <38	0.9%[s] 3.1%	NR NR	NR NR	NR NR
112	Lung resection	47		>8.8 <8.8	3.5%[s] 4.9%	NR NR	NR NR	NR NR
113	Lobectomy	37		>37 <19	3.5 4.3	NR NR	NR NR	NR NR

	Pneumonectomy	512			8.9 10.6	NR NR	NR NR	NR NR
114	Lung Resections	NR NR		>41 <8	≤4.9% ≥6.9%	NR NR	NR NR	6.6 5.4
34	Lobectomy	79 1806		>19 <2	4.2%[S] 6.4%	NR NR	NR NR	NR NR
115	Lung Resections	NR NR		≥35 <5	3.5% 6.9%	NR NR	NR NR	NR NR
116	Lung Resections	2 34		>66 <9	3.0%[S] 6.0%	NR NR	NR NR	33% 44%
117	Lung Resections	107 in-total		14-44 ≤5	5.2% 7.1%	NR NR	NR NR	NR NR
36	Pneumonectomy	NR NR		≥11 ≤ 5	10.7% 13.8%	NR NR	NR NR	NR NR
118	Lung Resections	206	822	0.3-3.8				37.5% [S*] 43.5%
119	Pneumonectomy, Lobectomy,	46 (pre regionalization) 15(post regionalization)	NR	Pre-post regionalization	Pneum: 10.9% to 5.6% [S] Lobe: 2.2% to 1.9 %	NR	NR	NR
120	Lung Resections	436	460	Quintiles Quintile 1 (1–2) Quintile 2 (3–6) Quintile 3 (7–12) Quintile 4 (13–23 Quintile 5 (≥24)	Q1: 3.52 (0.92–13.52) Q2: 0.85 (0.23–3.14) Q3: 0.82 (0.20–3.30) Q4: 0.37 (0.10–1.41) Q5: Reference	NR	NR	NR
121	Lobectomy	926(2007) 855(2008)	19831	Low (24/Year) Medium-Low (25–43/Year) Medium-High (44–67/Year) High (>68/Year)	Low:1.00 Medium-low: 0.68 (0.43–1.08) Medium-high: 0.82 (0.53–1.28) High :0.60 (0.36–0.99)	NR	Low: 15.9 (15.5–16.3) Medium Low: 13.1 (12.7–13.5) Medium High: 12.4 (12.0–12.7) High: 11.5 (11.2–11.8)	NR
122	Lung Resections	NR	13469	HV: teaching facility (TF); upper 1/3rd tertile by volume LV: non-teaching facility (NTF); lower 2/3 tertile by volume	TF:1.1%[S] NTF:2.6%[S] LVC: 2.7%[s] HVC: 1.6%[S]	NR	NR	TF:59.2% NTF:63.9%[S] LVC: 59.3%[s] HVC: 63.5%[S]

123	Lung Resections	NR	4878	average of cases/year VHV: >20 HV: 11—20 MV: 5—10 LV:0—4	NR (all data was reported as "not significant")	NR	NR	NR
124	Lung resections	540	72000 approx.	Cases during period: ≤24 25-49 50-99 100+	≤24: 1.4300 (0.9557– 2.1397) 25-49: 1.1062 (0.7461– 1.6399) 50-99: 1.0809 (0.7121–1.6406) 100+: reference	NR	NR	NR
71	Lung resections	79	4841	LV:1-135 MV:136-467 HV:468+	LV: reference MV: 0.72 (0.40–1.30) HV: 0.68(0.37–1.25)	NR	NR	NR
125	Lung resections	330	14456	Developed linear and non-linear models	NR	increasing the surgical volume from 10 to 30 procedures decreased the adjusted odds of inpatient death by 24% (OR= 0.76, 95% C.I. 0.65–0.90) when measured using prior 12 month volume and by 21% (OR =0.79, 95% C.I. 0.67–0.94) when measured using average annual volume.	NR	NR
126	Lung resections	NR		LV: <20 HV:≥20	HV: 0.76 (0.56 to 1.03)) LV: reference	NR	NR	NR
127	Thoracotomy?	19	2994	LV: 1—43 cases/year MV: 44—54 cases/ Year HV: 55 or more cases/year	LV: 7.6% MV:6.6% HV: 6.7%	NR	NR	LV: 0.4 MV:0.37 HV:0.38
128	Lung Resections	729	11668	LV: less than 90/year HV: 90+ a year	LV: 4.8% HV:3.2%	NR	NR	NR

5) Ovarian Cancer

Table 5a: Surgeon Specific Factors and Patient Outcomes, Ovarian Cancer

Study	Type of Resection	Specialty	Volume Categories (per year)	Total No. of surgeons over study period N (%)	Total No. of patients over study period N (%)	Mortality (%) [30-day unless otherwise specified]	Morbidity	Length of stay (days)	Overall Survival (%) (5-year unless otherwise specified)
55	Oophorectomy Staging/ Cytoreduction	NR	LV: <10 HV: ≥10	352	1894	LV: 4.05% HV: 1.69%[S+]	NR	Mean LV:8.85 HV:8.12	NR
22	Cytoreduction (debulking)		LV: ≤6 MV: 7-12 HV: >12	NR	1077	NR	NR	NR	OR: 0.7 (0.5-1) [HV vs. LV][+]
24	Ovarian cancer surgeries	Gyn/oncologists Gyn/obs General surgeon Other	LV: 1-2 MV: 3-9 HV: 10+	NR	3585	LV: 3.36 MV: 2.89 HV : 2.89	NR	NR	5 year mortality: LV: 48 MV: 36 HV: 48
58	Ovarian cancer surgeries	Gynecologic Oncologists, Gynecologists, or General surgeons	# cases per 8-year study period LV: 1-3 MV: 4-19 HV: 20-61	1365	2952	60-day: LV: 9.2 MV: 8.0 HV: 6.5	NR	LV: 6.1 MV: 4.1 HV: 3.3[+]	2 year mortality: LV: 43.2 MV: 42.9 HV: 39.5
24	Ovarian cancer surgery	Gyn/oncologists Gyn/obs General surgeon other	n/a	NR	3585	2.53 2.04 8.67 5.28	nr	nr	5 year: 35[+] 51[+] 25 (ref) 41
22	Cytoreduction (debulking)	Specialized Semi specialized General	n/a	NR	1077	NR	NR	NR	NS difference

Table 5b: Hospital-Specific Factors and Patient Outcomes, Ovarian Cancer

Study	Type of Resection	Total No. of Hospitals	No. of Patients	Volume Categories (per year)	Mortality [30-day] (%)	Morbidity	Length of stay (days)	Overall Survival (5-year)
55	Oophorectomy Staging/ Cytoreduction	43	1894	LV: <20 HV: ≥20	2.83 2.21	NR	Mean 8.97 8.01[+]	NR

24	Ovarian cancer surgery	NR	3815	LV:1-15 MV:16-99 HV:100+	3.7 2.6 0.9	NR	NR	45 45 37
58	Primary ovarian cancer surgery	423	2952 (65 and over)	# cases per 8-year study period LV: 1-3 MV: 4-19 HV: 20-61	60-day: 8.6 9.6 6.6	NR	5.5 5.7 3.5+	2-year Mortality: 45.2 41.1 40.4+
22	Ovarian cancer surgery	18 (random sample)	1077	LV: ≤6 MV: 7-12 HV: >12	NR	NR	NR	NS difference
59	Oophorectomy	1166	36624	Average annual volume over study period: 3 volume terciles	LV: 1.8 MV: 1.6+ HV: 1.5+	20.4 23.4S 24.6S+	20.1 18.2S 14.7S	NR
158	Overall treatment	40	2163	LV: ≤10 MV: 11-20 HV: ≥ 21	HV lower risk of death than LVS	NR	NR	LV lower risk of 4-year survival+
159	Gynecological cancer (all relevant organs)	9	3406	Observing changes in mortality after implementation of centralization guidelines	Relative hazard ratio (2006) 1996 diagnosis: 1.00 2003 diagnosis: 0.69 (0.56-0.86) 95% CI *significant reduction in hazard ratio post 2000		NR	NR
57	Stage IIIC and IV ovarian cancer	1430	45929	Annual average LV:<9 MV:9-20 HV:21-35 VHV:>35	Hazard ratio (very high volume referent), 95% C.I: LV:1.16 (1.09-1.24) MV: (1.01-1.15) HV: (0.98-1.09)	NR	NR	24.3% 26.1% 28.5% 28.9%
160	Ovarian cancer surgery	249	15131 (ovarian cancer patients)	Hospitals grouped by volume over entire period LV: lower tertile MV: middle tertile HV: highest tertile	LV:7.8% MV:5.5% HV:5.0%	NR	NR	NR
161	Ovarian cancer surgery	74	953	Hospitals classified according to hessian hospital legislation Primary care (28) Secondary care (28) Tertiary care(9) Central referral centres(9)	NR	Primary care: 0% Secondary care:14.9% Tertiary care:11.8% Referral centres: 17.1%	NR	NR

Table 5c: Hospital type and Patient Outcomes, Ovarian Cancer

Study	Hospital Type	Type of Resection	Volume Categories (per year)	Total No. of patients over study period	Mortality (%) [30-day unless otherwise specified]	Morbidity	Length of stay (days)	Overall Survival (Years)
56	Referral centres compared to regional hospitals	Stage IIIC and IV ovarian cancer	NR	2024			NR	Better survival for center patients was most noticeable in the first years after the diagnosis, and overall survival in centres and other hospitals appeared to be equal after approximately 5 years"
24	w/gynecologist other cancer specialist remaining	Ovarian cancer surgery	w/gynecologist other cancer specialist remaining	3815	w/gynecologist: 2.86% other cancer specialist:2.97% remaining:3.22%	NR	NR	5 year survival w/gynecologist:38% other cancer specialist:45% remaining: 46%
22	General Semi Specialized Specialized	Screening and debulking of ovarian cancer	LV:<=6 new cases/yr MV: 7-12 new cases a year HV: >12 new cases a year	1077				
156	District Hospitals Central hospitals University referral centres	Surgical treatment for ovarian cancer	District Hospitals Central hospitals University referral centres	307	NR	% with no macroscopic tumour post op: District: 19% Central:10% University: 34%	NR	NR
164	Low volume	Cytoreduction	All data taken from one low volume hospital	48	NR	27%	8.2 (optimal surgery) 11.3 (sub optimal surgery)	All patients survived (mean 37.1 months)
165	Large high volume centre (post regionalization policy)	"primary surgery"	Observations from the Gynecologic Oncologic centre in Aalborg – after regionalization policy implemented	107	3.7%	6.5%	NR	4 year survival : 49.2% Median 46 months

Appendix 2: ICD-10 diagnosis and intervention codes

Table: ICD-10 Diagnosis Codes

CANCER TYPE	ICD-10 DIAGNOSIS CODES
Esophageal Cancer	C150, C151, C152, C153, C154, C155, C158, C159, D377
Pancreatic Cancer	C250, C251, C252, C253, C254, C257, C258, C259
Liver Cancer	Primary: C220, C221, C222, C223, C224, C227, C229, D376 Secondary: C787
Lung Cancer	C3400, C3401, C3409, C3410, C3411, C3419, C342, C3430, C3431, C3439, C3480, C3489, C3490, C3491, C3499, C390, C398, C399, D381
Ovarian Cancer	C560, C561, C569, C5700, C5701, C5709, C571, C572, C573, C574, C578, D391

Table: ICD-10 Intervention Codes

	PROCEDURE NAME	INTERVENTION CODES
Esophageal Cancer Surgeries	Minimally invasive esophagectomy	1NA89DB, 1NA89FA, 1NA91DB, 1NA91FA, 1NA88DCXXG, 1NA88FCXXG, 1NA87FB, 1NA87FC, 1NA87DC, 1NA87DD, 1NA87EY, 1NA87EZ
	Open esophagectomy	1NA87QG, 1NA87QH, 1NA88LBXXG, 1NA88QFXXG, 1NA89LB, 1NA89QF, 1NA90LBXXG, 1NA90LBXXG, 1NA90QFXXG, 1NA91LB, 1NA91QF, 1NA92LBXXF, 1NA92LBXXG, 1NA92QFXXG, 1NA87LD, 1NA87LE, 1NA87QC, 1NA87QD
Pancreatic Cancer Surgeries	Distal pancreatectomy	1OJ87LA, 1OJ87VK, 1OJ87VC
	Minimally invasive distal pancreatectomy	1OJ87DA
	Whipple procedure	1OK87LA, 1OK87VZ, 1OK87WA, 1OK87XN, 1OK91LA, 1OK91XN, 1OK89LA, 1OJ89LA, 1OJ89VZ
Liver Cancer Surgeries	Minimally invasive liver resection	1OA87DA
	Open liver resection	1OA87LA, 1OA87LAAZ
Lung Cancer Surgeries	Vats sublobar resection	1GR87DA, 1GR87PN, 1GT87DA
	Open sublobar resection	1GR87NW, 1GR87QB, 1GT87NW, 1GT87QB
	Vats lobectomy	1GR89DA
	Open lobectomy	1GR89NW, 1GR89QB, 1GR91NW, 1GR91NWXXA, 1GR91NWXXG, 1GR91NWXXN, 1GR91QB, 1GR91QBXXA, 1GR91QBXXF, 1GR91QBXXG, 1GR91QBXXN, 1GR91QBXXQ
	Open pneumonectomy	1GT89NW, 1GT89QB, 1GT91NW, 1GT91NWXXF, 1GT91NWXXG, 1GT91NWXXN, 1GT91NWXXQ, 1GT91QB, 1GT91QBXXF, 1GT91QBXXG, 1GT91QBXXN, 1GT91QBXXQ
	Vats pneumonectomy	1GT89DA
Ovarian Cancer Surgeries	Minimally invasive oophorectomy	1RB87DA, 1RB89DA, 1RD89DA
	Open oophorectomy	1RB87LA, 1RB89LA, 1RD89LA

	Trans-vaginal oophorectomy	1RD89RA, 1RB87RA, 1RB89RA
	Minimally invasive fallopian tube resections	1RF87DA, 1RF89DA
	Open fallopian tube resection	1RF87LA, 1RF89LA
	Vaginal fallopian tube resection	1RF87RA, 1RF89RA
	Vaginal hysterectomy simple	1RM87BAGX, 1RM89CA, 1RM87CAGX
	Vaginal hysterectomy radical	1RM91CA
	Minimally invasive hysterectomy simple	1RM89AA, 1RM87DAGX, 1RM89DA, 1RM87DAAG
	Minimally invasive hysterectomy radical	1RM91AA, 1RM91DA
	Open hysterectomy simple	1RM89LA, 1RM87LAGX
	Open hysterectomy radical	1RM91LA
	Omentectomy	1OT87LA, 1OT87DA

Appendix 3: Data Selection and Methodology for CIHI Data Analysis

The pan-Canadian data (excluding Quebec) was extracted from the Canadian Institute of Health Information (CIHI) Discharge Abstract Database (DAD), which contains hospital records for in-patient admissions. Except for liver cancer, only cases with primary cancers and associated surgical procedure(s) over the 9-year period (2004-2012) were included in this analysis (See Appendix 2 ICD-10 diagnosis codes). Resections for primary liver cancer constitute one-third of all liver procedures, while the remaining procedures are performed for metastasized colorectal tumours. The expert surgeons identified high risk procedures within each cancer type. A list of ICD-10 procedure codes used for this analysis is presented in Appendix 2.

The outcomes of interest were in-hospital mortality at discharge, and length of hospital stay for those discharged alive, up to a maximum of 30 days. The exclusion of patients who experienced a length of stay beyond thirty days was selected because those patients would typically be more complicated case, and are not representative of the usual patient population. The crude mortality rates, averaged over the 9 year period, are presented as the simplistic representation of mortality rates over time in Canada. The low annual case volume for smaller provinces makes direct year-to-year comparisons between provinces challenging. For instance, the crude mortality rate for a province with annual case load of 20 surgeries can increase from 0% to 5% with one instance of in-hospital mortality. Therefore, 9-year age-adjusted mortality rates (using the Canadian population over the 9-year period as a standard) are presented for each province to facilitate more fair comparisons.

- Multivariate logistic regression analysis was performed to quantify the impact of patient-related factors (age, sex, and co-morbidities), procedural complexities, year, and system-specific factors (hospital volume, surgeon volume, surgeon specialty) on outcomes of interest. Hospital volume was used as a primary surrogate measure to assess the extent of consolidation of services since surgeon specialty is not reliably coded in administrative databases and accurate surgeon volume counts are obscured by instances of reused surgeon identification codes in multiple centres.
- The population size, and hence the number of surgeries, differs vastly amongst the provinces and territories of Canada. Given the small sample size for some provinces, statistical significance of outcome disparities between provinces could not be determined reliably in advanced analysis. Similarly, differences may exist between hospitals in both the quality and organization of care regardless of volume. Multi-level analysis was used to account for the differences between provinces (i.e. health care structure, policies, population health status) and hospitals on outcomes of care. Advanced survival analysis was performed to assess the impact of factors of interest on hospital length of stay. Where pertinent, provincial outcomes are reported compared to their peers although this was only possible with Ontario. As Ontario is the most populous province with a sufficient sample size, its results were compared with the rest of Canada in multivariate analysis in order to benchmark outcomes to a larger population by evaluating the deviations of outcomes in the province relative to the larger national mean.

- The analysis of travel times and evolution of hospital catchment areas was completed using Geographic Information System (GIS) methods utilizing ArcGIS software and Census Canada data. GIS is a uniquely integrative mix of hardware, software, and practices that enable spatial epidemiology – the geo-visualization of the distribution and determinants of health phenomena. GIS can assist in identifying the distribution of health events and health services, and allows the application of a spatial lens to the complex relationships between resources, procedure volumes, and outcomes. This technique allows us to descriptively map and analyze the distribution and trends of cancer surgery while stratified for institutional volume. Travel time was calculated using the first three digits of de-identified patient postal codes relative to the nearest surgical institution, adjusted for road network data such as speed limits, bodies of water and traffic lights. This work has resulted in figures that visually describe differences in health care delivery at 2004-2007and 2011-2012 cohorts.
- Age-standardized resection rates were calculated using 1991 Canadian population as a standard. The rates were presented as aggregated sum of number of surgeries in the first and last three years, divided by the adjusted provincial populations in the middle years (2005 and 2011, respectively) for each time period. The denominator, adjusted provincial populations in 2005 and 2011, were multiplied by 3 in order to obtain rates per person-years. For instance, the aggregated 3-year resection rate for first 3 years was calculated as:

$$\text{Aggregated 3-year Resection Rate} = \frac{(\text{Number of Surgeries from 2004-2006}) \times 100{,}000}{(\text{Age-adjusted Provincial Population in 2005}) \times 3}$$

- Potential Years of Life Lost calculated using method described by Urbach et al.[33] Potential number of hospital days were calculated using unadjusted median for the highest hospital volume category.

Appendix 4: In-hospital Mortality Analysis

Multivariate, Multilevel Regression Models:

1) Esophageal Cancer

Dependent Variable= Mortality [Odds Ratio greater than 1 means higher risk of in-hospital mortality]

	Odds Ratio	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	2.06	<0.001	[1.71-2.48]
Charlson Comorbidity Score	1.07	0.026	[1.01-1.13]
Fiscal Year (1 unit=1 year)	0.96	0.290	[0.90-1.03]
Ontario vs. Rest of Canada	0.71	0.128	[0.45-1.11]
Hospital Volume (1 unit=10 year increment)	0.60	0.030	[0.37-.95]
Surgeon Volume (1 unit=10 year increment)	1.78	0.094	[0.91-3.5]
General Surgeons (Thoracic Surgeon=Reference)	1.15	0.696	[0.57-2.3]

Significant Interactions:

	Odds Ratio	p-value	[95% Confidence Interval]
Surgeon Specialty* Hospital Volume • General Surgeon	2.43	0.011	[1.23-4.83]
Surgeon Specialty* Hospital Volume • General Surgeon	0.24	0.019	[0.08-0.79]

	Estimate	p-value	[95% Confidence Interval]
Hospital Clustering Effect	0.42	0.0242	[0.20-0 .87]

2) Pancreatic Cancer

Dependent Variable= Mortality [Odds Ratio greater than 1 means higher risk of in-hospital mortality]

	Odds Ratio	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	2.51	<0.001	[1.85-3.41]
Charlson Comorbidity Score	1.88	0.004	[1.22-2.88]
Sex (ref=Females)	1.28	0.154	[0.91-1.80]
Main Resection (ref=Distal Pancreatectomy) • Whipple Procedure	1.61	0.03	[1.04-2.49]
Fiscal Year (1 unit=1 year)	0.96	0.290	[0.9-1.03]
Bowel Resection	3.12	<0.001	[1.92-5.05]
Ontario vs. Rest of Canada	1.03	0.865	[0.69-1.56]
Hospital Volume (1 unit=10 year increment)	0.82	0.018	[0.7-0.96]
Surgeon Volume (1 unit=10 year increment)	1.03	0.86	[0.71-1.49]

Significant Interactions:

	Odds Ratio	p-value	[95% Confidence Interval]
Age*Comorbidity Score	0.92	0.011	[0.87-0.98]

	Estimate	p-value	[95% Confidence Interval]
Hospital Clustering Effect	0.30	0.067	[0.13-0.73]

3) Liver Cancer

Dependent Variable= Mortality [Odds Ratio greater than 1 means higher risk of in-hospital mortality]

	Odds Ratio	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	1.65	<0.001	[1.46-1.88]
Charlson Comorbidity Score	1.76	<0.001	[1.32-2.36]
Main Resection (Minimally Invasive=ref) • Open Liver Resection	2.58	0.01	[1.25-5.31]
Fiscal Year (1 unit=1 year)	0.91	0.025	[0.83-0.99]
Number of Liver Resections/visit	2.59	0.008	[1.27-5.27]
Ontario vs. Rest of Canada	0.89	0.468	[0.66-1.21]
Hospital Volume (1 unit=10 year increment)	0.99	0.61	[0.95-1.02]
Surgeon Volume (1 unit=10 year increment)	0.71	0.009	[0.55-0.92]

Significant Interactions:

	Odds Ratio	p-value	[95% Confidence Interval]
Surgeon Volume*Fiscal Year	1.04	0.03	[1-1.08]

	Estimate	p-value	[95% Confidence Interval]
Hospital Clustering Effect	0.12	0.38	[0.004-3.42]

4) Lung Cancer

Dependent Variable= Mortality [Odds Ratio greater than 1 means higher risk of in-hospital mortality]

	Odds Ratio	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	1.82	<0.001	[1.66-2]
Charlson Comorbidity Score	1.13	<0.001	[1.10-1.16]
Sex	1.79	<0.001	[1.52-2.11]
Main Resection (VATS Sublobar=ref) • Open Sublobar • VATS Lobectomy • Open Lobectomy • Pneumonectomy	 2.05 0.91 1.61 5.62	 <0.001 0.704 0.003 <0.001	 [1.5-2.82] [0.59-1.42] [1.17-2.23] [4.02-7.86]
Fiscal Year (1 unit=1 year)	0.97	0.044	[0.93-1]
Number of Lung Resections/visit	1.59	0.001	[1.22-2.09]
Ontario vs. Rest of Canada	0.87	0.222	[0.70-1.08]
Hospital Volume (1 unit=10 year increment)	0.97	.046	[0.95-1]
Surgeon Volume (1 unit=10 year increment)	0.99	0.57	[0.95-1]
General Surgeons (Thoracic Surgeon=Reference)	1.15	0.248	[0.91-1.45]

	Estimate	p-value	[95% Confidence Interval]
Hospital Clustering Effect	0.24	0.004	[0.14-0.43]

5) Ovarian Cancer

Dependent Variable= Mortality [Odds Ratio greater than 1 means higher risk of in-hospital mortality]

	Odds Ratio	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	3.22	<0.001	[2.4-4.3]
Charlson Comorbidity Score	2.62	<0.001	[1.71-4]
Main Resection (Minimally Invasive=ref) • Open Procedures	 1.33	 0.776	 [0.18-9.77]
Fiscal Year (1 unit=1 year)	0.95	0.09	[0.88-1.01]
Number of Gyne Resections/visit	0.58	<0.001	[0.46-0.74]
Ontario vs. Rest of Canada	1.27	0.19	[0.89-1.8]
Hospital Volume (1 unit=10 year increment)	0.93	0.012	[0.89-0.98]
Surgeon Volume (1 unit=10 year increment)	1.14	0.148	[0.95-1.35]
Surgeon Specialty (Obs/gyne=ref) • GyneOnc • General	 1.55 3.38	 0.058 <0.001	 [0.99-2.44] [1.96-5.83]

Significant Interactions:

	Odds Ratio	p-value	[95% Confidence Interval]
Age*Comorbidity Score	0.90	<0.001	[0.85-0.96]

	Estimate	p-value	[95% Confidence Interval]
Hospital Clustering Effect	---	---	---

Appendix 5: Survival Analysis

1) Esophageal Cancer

Dependent Variable= 30-day Length of Stay [Exp(b) less than 1 means higher chance of early discharge]

	Exp (b)	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	0.93	0.011	[0.88-0.98]
Sex	1.25	<0.001	[1.10-1.41]
Charlson Comorbidity Score	0.97	0.004	[0.95-0.99]
Fiscal Year (1 unit=1 year)	1.02	0.158	[0.99-1.05]
Main Resection (ref=Minimally Invasive) • Open Esophagectomy	0.67	0.004	[0.51-0.88]
Ontario vs. Rest of Canada	1.01	0.91	[0.82-1.25]
Hospital Volume (1 unit=10 year increment)	1.15	0.072	[0.98-1.36]
Surgeon Volume (1 unit=10 year increment)	2.06	<0.001	[1.38-3.10]
General Surgeons (Thoracic Surgeon=Reference)	1.14	0.133	[0.96-1.34]

Significant Interactions:

	Odds Ratio	p-value	95% CI
Surgeon Volume* Hospital Volume	0.80	0.009	[0.68-0.95]

2) Pancreatic Cancer

Dependent Variable=30-day Length of Stay [Exp(b) less than 1 means higher chance of early discharge]

	Exp(b)	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	0.90	<0.001	[0.87-0.93]
Charlson Comorbidity Score	0.98	0.003	[0.97-0.99]
Sex (ref=Females)	0.98	0.481	[0.91-1.05]
Main Resection (ref=Distal Pancreatectomy) • Whipple Procedure	0.31	<0.001	[0.25-0.39]
Fiscal Year (1 unit=1 year)	1.05	<0.001	[1.02-1.08]
Bowel Resection	0.48	<0.001	[0.41-0.57]
Cholecystectomy	0.89	0.028	[0.80-0.99]
Number of Pancreatic resections/year	0.48	0.006	[0.28-0.8]
Ontario vs. Rest of Canada	0.71	<0.001	[0.61-0.83]
Hospital Volume (1 unit=10 year increment)	1.12	<0.001	[1.06-1.17]
Surgeon Volume (1 unit=10 year increment)	1.34	0.011	[1.06-1.68]

Significant Interactions:

	Odds Ratio	p-value	[95% Confidence Interval]
Surgeon Volume* Hospital Volume	0.93	0.001	[0.90-0.98]

3) Liver Cancer

Dependent Variable= 30-Day Length of Stay [Exp(b) greater than 1 means higher likelihood of shorter length of stay

	Exp(b)	**p-value**	**[95% Confidence Interval]**
Age (1 unit=10 year increment)	0.91	<0.001	[0.88-0.92]
Sex	0.98	0.631	[0.94-1.04]
Charlson Comorbidity Score	0.93	<0.001	[0.92-0.95]
Main Resection (Minimally Invasive=ref) • Open Liver Resection	0.43	<0.001	[0.33-0.55]
Fiscal Year (1 unit=1 year)	1.03	0.005	[1.01-1.05]
Secondary Cancer (ref=Primary)	1.33	<0.001	[1.24-1.42]
Ontario vs. Rest of Canada	0.88	0.026	[0.78-0.99]
Hospital Volume (1 unit=10 year increment)	1.01	0.511	[0.99-1.01]
Surgeon Volume (1 unit=10 year increment)	1.05	0.010	[1.01-1.09]

4) Lung Cancer

Dependent Variable= 30-day Length of Stay [Exp(b) less than 1 means higher chance of early discharge]

	Exp(b)	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	0.89	<0.001	[0.87-0.90]
Charlson Comorbidity Score	0.97	<0.001	[0.96-0.98]
Sex	0.94	<0.001	[0.92-0.97]
Main Resection (VATS Sublobar=ref) • Open Sublobar • VATS Lobectomy • Open Lobectomy • Pneumonectomy	 0.45 0.75 0.32 0.27	 <0.001 <0.001 <0.001 <0.001	 [0.35-0.58] [0.66-0.85] [0.26-0.42] [0.22-0.33]
Fiscal Year (1 unit=1 year)	1.05	0.003	[1.01-1.07]
Number of Lung Resections/visit	0.85	0.002	[0.77-0.94]
Ontario vs. Rest of Canada	0.84	0.039	[0.71-0.99]
Hospital Volume (1 unit=10 year increment)	1.01	0.012	[1.00-1.02]
Surgeon Volume (1 unit=10 year increment)	1.04	0.017	[1.01-1.08]
General Surgeons (Thoracic Surgeon=Reference)	1.14	0.065	[0.99-1.31]

5) Ovarian Cancer

Dependent Variable= 30-day Length of Stay [Exp(b) less than 1 means higher chance of early discharge]

	Exp(b)	p-value	[95% Confidence Interval]
Age (1 unit=10 year increment)	0.87	<0.001	[0.84-0.90]
Charlson Comorbidity Score	0.93	<0.001	[0.92-0.94]
Main Resection (Minimally Invasive=ref) • Open Procedures • Radical Hysterectomy • Omentectomy	 0.26 0.10 0.06	 <0.001 <0.001 <0.001	 [0.21-0.32] [0.07-0.16] [0.03-0.09]
Fiscal Year (1 unit=1 year)	1.1	<0.001	[1.04-1.07]
Ontario vs. Rest of Canada	0.88	0.167	[0.74-1.05]
Hospital Volume (1 unit=10 year increment)	1.03	0.018	[1.01-1.06]
Surgeon Volume (1 unit=10 year increment)	0.90	<0.001	[0.87-0.93]
Surgeon Specialty (Obs/gyne=ref) • GyneOnc • General	 0.90 0.51	 0.315 <0.001	 [0.73-1.10] [0.44-.57]
Bowel Resection	0.45	<0.001	[0.44-0.48]
Number of Gyne Resections/visit	0.95	<0.001	[0.92-0.98]

Appendix 6: Citizen Panel Methodology

The citizen panels were convened in Autumn 2014 in three cities: Hamilton (Ontario), Edmonton (Alberta), and Charlottetown (Prince Edward Island). These locations were purposefully selected to reflect different degrees of regionalization for complex cancer surgeries and access to surgical centres of excellence. In particular, there have been active efforts in Ontario to regionalize some complex cancer surgeries, the creation of surgical centres of excellence and the development of guidelines about minimum-volume standards for surgical sites and surgeons by Cancer Care Ontario. In Alberta, there has been a passive form of regionalization for some surgical procedures over the years. The transition took place in large part because surgeons preferred to provide care in a team setting rather than on their own. In contrast, **very few complex cancer surgeries have been performed in Prince Edward Island (PEI) over the last 9 years,** and patients must travel to a neighbouring-province to access complex cancer surgeries (most often Nova Scotia).

Each panel consisted of a one-day structured deliberation facilitated by a member of the research team and included deliberations about the problem, three options to address the problem, and implementation considerations. The brief, which was circulated one week prior to each panel, was taken as read for each panel, allowing the deliberations to build on the pre-circulated material to generate rich insights from panel members. The citizen panels did not aim for consensus. However, it aimed to highlight areas of common ground and differences of opinion among panel members and (where possible) identify the values underlying different positions.

The study protocol was approved by the Hamilton Integrated Research Ethics Board at McMaster University and all panel members provided voluntary, informed consent. For those who are interested in obtaining more information about the citizen brief, it is freely available on the McMaster Health Forum website (www.mcmasterhealthforum.org).

Preparing the citizen brief

We prepared the citizen brief through four main steps. First, we convened a steering committee comprised of representatives from the McMaster Health Forum, as well as clinicians and researchers from McMaster University who were involved in a broader program of research about complex cancer surgeries. The role of the steering committee was to provide guidance and expert advice across all stages of the process.

Second, in collaboration with the steering committee, we developed terms of reference for the citizen brief, which provided a preliminary outline of the framing of the problem, three options for addressing it, and implementation considerations (i.e., barriers and facilitators for moving forward). We then conducted ten key informant interviews with policymakers, managers (e.g., from health regions and healthcare institutions), stakeholders (e.g., from provider associations or cancer societies) and researchers who were actively engaged in the issue of complex cancer surgeries. The terms of reference were iteratively revised based on feedback from the key informants and the steering committee and then used to structure the writing of the citizen brief.

Third, we identified, selected, appraised and synthesized relevant research evidence about the problem, three options (among many) to address it, and implementation considerations. Whenever possible, we summarized research evidence drawn from systematic reviews and occasionally from

single studies when reviews were not identified. We identified published literature that provided an understanding of the problem by searching PubMed to identify published literature. In addition, we searched for grey literature about the problem by reviewing the websites of a number of Canadian and international organizations. To identify research evidence about the three options in the brief, we searched Health Systems Evidence (www.healthsystemsevidence.org), which is a continuously updated database that now contains more than 4,000 systematic reviews of delivery, financial and governance arrangements within health systems. The reviews were identified by searching the database for 'cancer' and 'surgery' in the title and abstract, and by searching topic categories addressing features of each of the options (e.g., 'quality monitoring and improvement systems' and 'regionalization'). The searches were reviewed for relevance by the lead author of the brief (FPG).

Fourth, we synthesized key findings in the form of a citizen brief. Specifically, we drafted the brief in such a way as to present concisely and in accessible language the research evidence. The final version of the brief consisted of a description of: 1) the context for the panel; 2) the problem; 3) three options (among many) to address it; 4) implementation considerations; and 5) the questions to be discussed during the citizen panels. The brief also contained a separate insert for each panel, which described particular features of the local health system. We then undertook a merit review process for the brief, which was reviewed by one public/patient representative, one policymaker, one stakeholder, and one researcher in order to ensure its system relevance, its scientific rigour and its accessibility.

Convening the citizen panels

We worked collaboratively with the steering committee to plan and convene the three citizen panels. Two strategies were implemented to recruit potential candidates: 1) targeted invitations sent to the AskingCanadians™ panel (a market-research panel of more than 600,000 Canadians who have opted-in to participate in online surveys); and 2) targeted online advertisements via cancer organizations and societies. We selected 10-14 panel members for each panel based on explicit criteria (e.g., experiences as patients or informal/family caregivers, experiences with cancer and surgeries, types of cancer, gender, socioeconomic and ethno-cultural background). We describe the profile of panel members for each panel in Appendix 9. The study protocol was approved by the Hamilton Integrated Research Ethics Board at McMaster University and all panel members provided voluntary, informed consent.

Each panel consisted of a one-day structured deliberation facilitated by a member of the research team (JA or FPG) and included deliberations about the problem, three options to address the problem, and implementation considerations. The brief, which was circulated one week prior to each panel, was taken as read for each panel, allowing the deliberations to build on the pre-circulated material to generate rich insights from panel members. The citizen panels did not aim for consensus. However, it aimed to highlight areas of common ground and differences of opinion among panel members and (where possible) identify the values underlying different positions.

Appendix 7: Features of the problem of delivering complex cancer surgeries as described in the citizen brief

Issue	Factors contributing to the issue
Cancer represents a significant burden on individuals, the health system and society	• With population growth and aging, the number of new cases of cancer in Canada is expected to increase. • Since surgery is the primary treatment option for certain high-risk cancers, the costs associated with cancer surgeries are expected to rise over time.
Patients in need of complex cancer surgeries and their families face a difficult journey	• Patients and families have to make complex and potentially life-changing decisions (e.g., undergoing surgery or not, undergoing surgery at a local low-volume hospital or travelling to a high-volume hospital with the hope of better outcomes), but information to guide such decisions is often not readily available. • The long-term outlook for those diagnosed with any of these five types of cancer is generally quite intimidating, since a significant number of patients will die despite curative-intent surgery.

The health system is not currently designed to provide optimal care for such patients	• *Delivery arrangements*
	  ○ There are disparities in access to complex cancer surgeries across Canada and even in settings that have access there are disparities in the availability of expertise to conduct these surgeries. In some provinces, the surgeries are being delivered in any hospital setting, without restriction. There have been efforts to regionalize (or centralize) some of these complex cancer surgeries into high-volume centres (i.e., centres providing surgical care to many patients) in a few provinces.
	  ○ There is a lack of support for the informal and family caregivers of the patients undergoing complex cancer surgery.
	• *Financial arrangements*
	  ○ The predominant funding model for Canadian hospitals (i.e., global budgets) provides little incentive for hospitals to focus on increasing surgery volumes, improving quality of care, or coordinating care across facilities and sectors.
	• *Governance arrangements*
	  ○ There is minimal regulation as to which procedures surgeons can perform within their specialty area, or how frequently they need to perform these procedures to ensure their surgical skills remain up to date.
	  ○ There is minimal regulation as to which procedures can be performed in hospitals or how frequently they need to perform them to ensure that quality remains high. In addition, most hospitals are regulated by legislation that establishes an appeal process for doctors who feel aggrieved by decisions made by hospital boards, which can make it difficult to change where different types of surgical procedures can be performed.
	  ○ There is a lack of coordinated effort among all stakeholders to improve complex cancer surgeries across the country (e.g., no agreed set of quality indicators at the pan-Canadian level).

Appendix 8: Three options for improving the delivery of complex cancer surgeries in Canada

Option	Option focus and elements
1 - Encourage the local adoption of quality-improvement initiatives to improve the delivery of complex cancer surgeries where they are now being provided	• The first option aims to encourage healthcare providers (e.g., surgeons, nurses and others) and managers to adopt quality-improvement initiatives in local hospitals in order to improve the delivery of high-risk and resource-intensive cancer surgeries. This option assumes that healthcare providers and hospital managers will adopt quality-improvement initiatives without the need for supports, incentives or directives to change behaviour, and without the need for regulatory changes about where (and by whom) these cancer surgeries can be provided. In sum, this option proposes a locally driven approach to improve the delivery of cancer surgeries. • There are a large number of quality-improvement strategies that can be driven locally by healthcare providers and hospital managers, for example: o Promoting audit and feedback; o Promoting the use of clinical decision support systems; o Promoting continuing medical education; and o Implementing enhanced recovery programs.
2 - Implement province-wide quality-improvement initiatives to improve the delivery of complex cancer surgeries where they are now being provided	• The second option aims to implement province-wide* quality-improvement initiatives to improve the delivery of complex cancer surgeries. Like the first option, this option is not intended to change where and by whom these cancer surgeries are being provided. However, in contrast to the first option, this option proposes a top-down approach to quality improvement and assumes that healthcare providers and hospital managers can achieve significant improvements, but that they need appropriate support, incentives and directives to do this. • These province-wide quality-improvement initiatives could take different forms, for example: o Developing provincial guidelines and standards for these cancer surgeries; o Implementing pay-for-performance for hospitals; o Developing or expanding supports for patients and families; and o Establishing requirements for reporting to the public about quality indicators and other performance measures.
3 – Regionalize complex cancer surgeries into designated surgical centres of excellence	• The third option aims to regionalize complex cancer surgeries into designated surgical centres of excellence. This option includes efforts to change the structure of the health system and to set province-wide standards to support the regionalization of complex cancer surgeries. This option assumes that changes to who performs the surgeries and where they are performed will be needed to improve the delivery of care. This option proposes a top-down, province-wide approach to design and implement changes to who does what and where across the province. As with option 2, this option can include developing or expanding supports for patients and families.

* For small provinces, province-wide should be taken to mean across the small province or across both the small province and a neighbouring, larger province to which referrals are frequently made.

Appendix 9: Profile of panel members

		Hamilton panel (Ontario)	Edmonton panel (Alberta)	Charlottetown panel (PEI)
How many panel members?		14	13	11
Where were they from?		Hamilton-Niagara-Haldimand-Brant Local Health Integration Network	Within two hours driving distance from Edmonton	PEI (10) and rural Nova Scotia (1)
Participant Age	25-44	21%	7%	0%
	45-64	36%	54%	70%
	65+	43%	39%	30%
Participant Gender	Men	50%	38%	64%
	Women	50%	62%	36%
What was the educational level of panel members	No schooling	0%	0%	0%
	Elementary school	0%	8%	0%
	High school	14%	17%	20%
	Community college	14%	33%	20%
	Technical school	14%	0%	30%
	Bachelor's degree	50%	42%	30%
	Post-graduate training	7%	0%	0%
What was the work status of panel members?	Self-employed	0%	10%	10%
	Working full-time	29%	20%	20%
	Working part-time	7%	20%	10%
	Unemployed	0%	0%	0%
	Retired	36%	40%	50%
	Student	7%	0%	0%
	Homemaker	0%	0%	0%
	Disabled	21%	10%	10%
What was the income level of panel members?	Less than $20,000	21%	17%	10%
	$20,000 and $40,000	29%	25%	30%
	$40,000 and $60,000	21%	33%	20%
	$60,000 and $80,000	0%	0%	20%
	More than $80,000	14%	8%	10%
	Preferred not to answer	15%	17%	10%

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