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Ana Johnson

and

Thérèse Stukel

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Medical Practice Variations in Cancer Surgery

Devon Richardson¹, David Urbach² and Nancy Baxter³

(1)Division of General Surgery, University of Toronto, Toronto, ON, Canada

(2)Division of General Surgery, Toronto General Hospital, University Health Network, 200 Elizabeth Street, M5G 2C4 Toronto, ON, Canada

(3)Division of General Surgery, University of Toronto, St. Michael's Hospital, 30 Bond St. 16CC-040, M5B 2H9 Toronto, ON, Canada

Devon Richardson (Corresponding author)

Email: devon.richardson@dal.ca

Email: dprichar@dal.ca

David Urbach

Email: david.urbach@uhn.on.ca

Nancy Baxter

Email: baxtern@smh.ca

Abstract

The treatment of cancer is multidisciplinary; however, surgeons take an active role in the care of most cancer patients. Variation in cancer surgery may occur because care is provided by many surgeons practicing in different clinical settings. Several methods exist for assessing variations in cancer surgery including the evaluation of time trends, geographic variation, system comparisons, volume-outcome relationships, and disparities. Each of these methods is examined using examples from the literature along with specific weaknesses of each method. In addition two specific examples using population-based data from Ontario are presented which evaluate the surgical care of breast and colorectal cancer.

Introduction

Cancer is a leading cause of death. In 2008, there were approximately 12.7 million cancer cases and 7.6 million deaths attributable to cancer worldwide (Ferlay et al. [2010](#)). The most common cancers causing death include lung, breast, colorectal, stomach, and prostate (Ferlay et al. [2010](#)). In developed countries, rates of prostate, colorectal, breast, and lung cancers are higher compared to developing countries. In contrast, rates of cancer related to infection (stomach, liver, cervical cancer) are higher in developing countries (Jemal et al. [2011](#)).

The treatment of cancer is multidisciplinary and in many cases involves surgeons, medical oncologists, radiation oncologists, radiologists, and pathologists. Surgeons take an active role in the care of most cancer patients; surgeons are often the first health professional a patient is referred to when a diagnosis of cancer is suspected. They are responsible for obtaining a tissue sample to confirm the diagnosis and for coordinating other tests required to stage the cancer. In many circumstances, surgeons remove tumors with the expectation of curing the patient. Following surgery, the surgeon must decide if the patient should be referred for medical oncology or radiation oncology consultation, functioning as the “gatekeeper” to other cancer services. Finally, the surgeon often coordinates postoperative surveillance of the cancer.

Because of the importance of surgical involvement in the care of most solid tumors, there is much interest in studying the quality of surgical cancer care with the intent of improving the delivery of care. Studies of the quality of cancer care can be classified as those that examine the structure, process, or outcomes of care. Studies that examine the structures of cancer care look at factors such as clinician characteristics, or organizational characteristics of institutions that provide care such as presence of multidisciplinary tumor board conferences, and cancer center status. The processes of care are what health-care providers do for patients. The process of care research examines whether the right choices were made in diagnosing and treating the cancer, as well as whether care was provided in an effective and skillful manner. Finally, studies of outcome may examine the clinical or functional status of patients or patient satisfaction.

Because surgery for cancer is provided by a wide variety of surgeons in different clinical settings and most cancer surgery is performed in community hospitals by nonspecialist surgeons, surgical decision-making is unlikely to be uniform. Variation in surgical decision-making can vary across time, geographic region, health-care systems, surgeon/hospital characteristics, and patient groups. Variation in surgical care may affect the quality of care provided to patients as surgical decision-making will be directly related to both clinical and functional patient outcomes.

The remainder of the chapter will focus on variations in cancer surgery. The common methods for assessing variations are presented including the evaluation of time trends, geographic variation, system comparisons, volume-outcome relationships, and disparities. Two specific examples using population-based data from Ontario will be presented which evaluate the surgical care of breast and colorectal cancer.

Variations in Cancer Surgery

Time Trends

Time trends are a type of longitudinal study that can give researchers an overview of a population’s changing health status and treatment patterns. The data are collected at a population level over time to look for changes and trends in factors such as rates of disease and death. These studies may focus on patterns of change in an indicator over time, comparing one time period to another and comparing one geographic area to another, and may make future projections. These data are not intended to demonstrate causality, but can be used to generate hypotheses for further research. Time trend patterns can be described according to secular trends; the secular trend is the general component that changes over time. It represents long-term changes in health-related states such as survival. Two main methods of quantifying cancer patient survival are typically used: cancer-specific survival and relative survival (Sarfati et al. [2010](#)). Cancer-specific survival uses cancer-specific deaths as the end point of

interest, and patients who die from other causes are “censored.” An important potential source of bias in estimating cancer-specific survival is the misclassification of the cause of death. This can occur either because of poor data quality or because deaths are not correctly classified as cancer-specific deaths. In contrast relative survival uses death from any cause as the end point of interest. The observed survival of patients is then compared to mortality rates of an external comparison population. The main source of bias in this estimate is whether the two groups are comparable. Both cancer-specific survival and relative survival can be useful in different contexts. In descriptive, population-based, secular studies, relative survival may be the more appropriate measure. Secular trends are tracked over years and decades. The period that a secular trend is measured is in reference to the specific question that is being investigated. The existence and measurement of secular trends must be established by examination of the data themselves because the direction and extent of change may be different in different series.

Improvements in survival over the decades have been reported for a number of cancers (Birgisson et al. [2005](#); Gockel et al. [2007](#)), and in some cases improvements have been the result of changes in preoperative planning, operative techniques, and/or perioperative care. In Sweden, a population-based analysis of the time trends in curative surgery for pancreatic cancer has been analyzed (Linder et al. [2007](#)). All patients with a diagnosis of pancreatic duct cancer during the time period 1980–2000 were identified from a centralized national cancer registry (16,758 patients). Patients were classified as undergoing pancreatic resection, palliative intervention, or no invasive therapy based on the coding of interventional procedures. The study period was divided into three time intervals: 1980–1986, 1987–1993, and 1994–2000. The resection rate of pancreatic cancer significantly increased over the three study periods with reported resection rates of 7.2 % in the 1980–1986 time period, 10.9 % in 1987–1993, and 15.1 % in 1994–2000. During the three time periods, the number of palliative procedures decreased, as did the proportion of patients in whom no intervention was possible.

Changes in operative technique have led to reduced local recurrence and improved oncologic outcomes in certain cancers. In the management of rectal cancer, the traditional technique of removal of the rectum involved “blunt” dissection that disrupted the lymphovascular tissue around the rectum. This method resulted in relatively high local recurrence rates that were felt to be the result of residual lymphovascular tissue in the pelvis. A method of rectal dissection involving meticulous sharp dissection of the rectum along with its undisturbed lymphovascular tissue was developed and resulted in a significant improvement in the local recurrence of this cancer (Heald et al. [1998](#)). This method of dissection (total mesorectal excision or TME) has become the gold standard in the surgical treatment of rectal cancer. In the Netherlands, a randomized controlled trial was performed between 1996 and 1999 to assess the effect of preoperative radiation therapy on local recurrence and overall survival in patients who underwent TME surgery. In preparation for this trial, all participating surgeons were trained in the TME technique using workshops involving dissections labs, videos, and information booklets. In 2008, a study was published to evaluate overall survival in patients with rectal cancer who were treated by surgeons involved in the randomized controlled trial in the time periods before, during, and after the introduction of TME surgery combined with preoperative radiation (den Dulk et al. [2008](#)). Patients were identified from the population-based cancer registries in the region. Time was classified into three study periods: 1990–1995 (pretrial period), 1996–1999 (trial period), and 2000–2002 (posttrial period). The results of the study show a significant increase in overall survival across the three time periods: overall survival rates were 56 % in the pretrial period, 62 % during the trial period, and 65 % in the posttrial period. On multivariate analysis of overall survival, the time period during which the patient was treated was significant after controlling for age, sex, cancer stage, lymph node status, and systemic therapy. The results of this study suggest that overall survival of patients who underwent potentially curative surgery for rectal cancer improved after the introduction of TME

surgery. The training of surgeons in this technique was done successfully with effects that lasted beyond the trial period (den Dulk et al. [2008](#)).

Innovations in surgical technology have also led to improvements in patient outcomes. The use of mechanical staplers has allowed technically challenging and time-consuming anastomoses (reconnecting the gastrointestinal tract following removal of a portion) to become more manageable and in some instances has allowed anastomoses to be performed through smaller surgical incisions. Hemostatic agents (topical treatments for controlling surgical bleeding) are another innovation in surgical technology and have been developed for use as a complement to conventional methods. They are used to control persistent bleeding after conventional hemostatic techniques have failed or when abundant bleeding has led to biologic hemostatic disorders.

The use of time trends in health services research has limitations. There may be migration of populations during the study period, information on exposure and outcome may be collected in different ways for different populations, data may have been collected for other purposes and are missing critical details, and these types of study do not allow comment on the risks of an individual patient. Importantly there are numerous co-interventions and confounders which can make the results of these studies difficult to interpret. In the rectal cancer study outlined above, the introduction of the TME dissection technique occurred during the same time period as the introduction of preoperative radiation therapy, and it is therefore impossible to definitively attribute all improvement in outcome to changes in surgical technique. Over the past two decades, there have been tremendous improvements in cancer care. For example, the use of adjuvant and neoadjuvant treatments in the management of cancer has increased over time (Birgisson et al. [2005](#); Gockel et al. [2007](#); Hebert-Croteau et al. [1999](#)) with randomized controlled trials confirming benefit (Cunningham et al. [2006](#); Fisher et al. [1985](#); Sauer et al. [2004](#)). Improvements in staging (determining the extent of the cancer at the time of diagnosis) cancer over time have allowed surgeons to better select patients who will benefit from surgery. Patients with distant metastases or unresectable cancer identified by diagnostic imaging would not undergo surgery, and this may result in the apparent improvement in patient survival over time (the “Will Rogers” phenomenon). Even though the outcomes have improved, cancer patients actually have increased the number of their comorbidities over time (van Leersum et al. [2013](#)). The increase in comorbidities is especially prominent in patients 80 years and older. In many studies that analyze time trends, patient comorbidity data is not available, and this may diminish any observed improvements in survival patterns of cancer patients over time. Although time trends may provide a useful overview of changes in surgical care and outcomes for cancer patients, because of the multiple co-interventions and changes in the patient population, such studies are generally considered hypothesis generating.

Geographic Variation

Small-area analysis techniques have been used for over 50 years in health services research to measure variation across geographic groups. This method analyzes the variation in utilization of health care in small geographic or demographic areas. Traditionally, small-area studies were used to compare outcomes such as perinatal mortality, attempted suicides, vaccination uptake, and cancer deaths across geographic regions using routine data sources such as census and population estimates, vital statistics, and hospital utilization data. Performing a small-area analysis requires that the researcher identifies and defines the geographic boundaries of each small area, estimates the amount of resources allocated to each small area, and calculates descriptive statistics. Two main statistical techniques are used for these studies: direct comparison of rates between areas of interest and

correlation analyses to establish general relationships between health indicators and various social and economic characteristics.

When evaluating surgical cancer care, the primary goal of small-area variation analysis is to identify geographic variation in surgery, rather than underlying medical differences in the population. When variations are identified, they may be interpreted to suggest the procedure evaluated is underutilized in some areas, overutilized in some areas, or both. Underutilization of potentially curative surgery for cancer may be related to a number of variables including patient age, ethnicity, SES, education, insurance status, tumor characteristics, institution factors, and surgeon factors (Lazovich et al. [1991](#); Riall and Lillemoe [2007](#)). For example, the regional variation in the receipt of cancer-directed surgery for patients with epithelial ovarian cancer in the Medicare population in the United States has been described (Fairfield et al. [2010](#)). The study cohort included women in the SEER-Medicare data set with a diagnosis of epithelial ovarian cancer older than 65 years between 1998 and 2002. Geographic regions were assessed using hospital referral regions (HRRs) which represent markets for tertiary medical care. Cancer-directed surgery was defined as resection of the primary tumor. The study included 4,589 women with ovarian cancer of whom 71.6 % underwent cancer-directed surgery.

Variation in the use of cancer-directed surgery for ovarian cancer across the HRRs was found; rates of surgery ranged from 53 % to 88 %. On multivariate analysis of cancer-directed surgery controlling for demographic variables (income and education), age, stage, race, and percentage of non-English speakers according to census tract, HRR was a significant predictor of undergoing cancer-directed surgery. Because the variation in surgery could not be attributed to patient factors, access to cancer-directed surgery may account for some of the variation. Improving access to high-quality surgical care may improve outcomes for women with ovarian cancer.

There are methodological concerns with small-area research. The definition of a small area may differ between studies. Counties or health districts (groups of counties) are often used to define small areas; however, in counties or health districts with large population sizes and/or heterogeneous populations, such area designations may not be useful. The smallest and most widely used “small areas” in the United States are census block groups, which usually contain relatively homogenous populations. However, health data are not typically identified by a census block group, and therefore, census areas may not be the most useful way to study small areas. Zip code or postal code areas are discrete geographic areas that can be more easily linked to health data. It is important that the population size and event rate within a small area be large enough for analysis. If the number of events within a population is very low, precision of the estimation of the event rate will be low making between-area comparisons difficult. Small numbers of events may also compromise the privacy of individuals within the small area. Methods of overcoming a low number of events include the aggregation of data over a number of years or collapsing a number of small areas into a smaller number of regions. Small areas with 40,000–60,000 people produce an acceptable number of events for analysis to be performed (Haggard et al. [1998](#)), although this depends on the event of interest. Aggregation across years should be performed only if the area characteristics do not change over time. Aggregating small areas can be challenging because it can be difficult to know which areas to combine (Carstairs [1981](#)). There are specific challenges when using small-area variations to study surgical care. Some patients seek care in a hospital outside of their small area because of greater availability of services and facilities.

In many surgical studies the small area of interest is a region. Compared to a small area, regions tend to be a description of a larger area with loosely defined borders. Regional variation in the type of cancer surgery performed has been reported in multiple countries for a wide variety of cancer types. Over the last decade, the delivery of surgical services and cancer-specific services has become increasingly centralized. This centralization may have led to a vulnerability of cancer patients who

live in rural settings. A study of colorectal cancer patients (Baldwin et al. [2008](#)) revealed that over 90 % of rural CRC patients lived within 30 miles of a hospital offering colorectal surgery, but less than 50 % of these patients lived within 30 miles of a medical or radiation oncologist. The ability of these patients to travel in order to obtain treatment from medical and radiation oncology will have an impact on cancer recurrence and survival.

In the management of early breast cancer, the decision to offer breast-conserving surgery rather than mastectomy is partly based on the patients' ability to undergo adjuvant radiation therapy, which requires daily travel to the institution where radiation therapy is delivered. Patients who live in rural settings, remote from radiation therapy facilities, may be at a disadvantage. Variations in the use of breast-conserving surgery as opposed to mastectomy have been reported in the United States (Sariego [2008](#)), the United Kingdom (Sariego [2008](#)), Spain (Ridao-Lopez et al. [2011](#)), and Italy (Sant et al. [2012](#)). The rates of breast-conserving surgery relative to mastectomy vary from country to country, ranging from 19 % to 58 % (van Nes et al. [2010](#)). A US study published in 1992 (Nattinger et al. [1992](#)), shortly after the publication of trials establishing the safety of breast-conserving therapy, examined variation in breast cancer surgery using the national records on Medicare claims for inpatient hospital care. Patients were identified using ICD-9 diagnostic codes, and only women over the age of 65 years with invasive breast cancer were included. Patients were excluded if they underwent diagnostic biopsy only, had bilateral mastectomy, had metastatic disease at presentation, or did not have a diagnostic code for breast cancer at the time of their most invasive surgery. In total 36,982 patients were included in the study. Of these, 12.1 % had breast-conserving surgery, 80.2 % had modified radical mastectomy, 4.8 % had a simple mastectomy, and 2.9 % had a radical mastectomy. The proportion of patients undergoing breast-conserving therapy varied across the country with rates ranging from 3.5 % to 21.2 %. Rates of breast-conserving therapy also varied according to the size of the metropolitan area of the treating hospital. Patients treated in hospitals located in a metropolitan area (population greater than 2,500,000) were three times more likely to undergo breast-conserving therapy than patients treated in hospitals located in nonmetropolitan areas. This study also looked at the impact of hospital characteristics on the use of breast-conserving therapy for breast cancer and found that patients treated in hospitals with medical school affiliations, those designated as cancer centers, and hospitals with facilities for radiation therapy were more likely to receive breast-conserving therapy. The hospital characteristics that independently predicted the use of breast-conserving therapy were the size of the metropolitan area where the hospital was located, affiliation with a medical school, and availability of radiation therapy. This study demonstrates that even after the publication of trials establishing the safety of breast-conserving surgery in breast cancer, there is variation in the surgical management of breast cancer.

Breast-conserving therapy should be followed by radiotherapy to minimize risk of local recurrence. Radiotherapy protocols after breast-conserving surgery require daily treatments for several weeks and can be difficult for some patients to adhere to, especially if they do not live in close proximity to a radiation treatment facility. There have been multiple studies performed examining the impact of distance to a radiation facility and mastectomy rate. A population-based study linking the Florida incident cancer registry data to administrative inpatient and outpatient data tested the hypothesis that patients who live farther away from radiation therapy facilities were more likely to undergo a mastectomy rather than breast-conserving surgery with radiation (Voti et al. [2006](#)). Only patients with breast cancer who underwent one of these treatments were included in the analysis. Patient distance to the closest radiation facility was determined by geocoding the patients' addresses at diagnosis using the census-provided Topologically Integrated Geographic Encoding and Referencing (TIGER) files. The closest radiation therapy facility to the patient was identified using geographic information systems software, and the shortest distance to that facility was calculated. The study included 18,903

patients; 7,549 underwent mastectomy, and 11,354 underwent breast-conserving surgery with radiation. On average, women who received breast-conserving surgery with radiation lived closer to radiation treatment facilities than women who underwent mastectomy. After controlling for age at diagnosis, race/ethnicity, facility type, marital status, and insurance type, increased distance to the closest radiation therapy facility was negatively associated with receipt of breast-conserving surgery with radiation. The odds of receiving breast-conserving therapy decreased by 3 % for every 5-mile increase in the distance to the nearest radiation therapy facility. This study did not take into account patients who may have undergone breast-conserving surgery without radiation therapy nor did it include any information on the size of the tumor (which influences the type of procedure performed). Further, the Euclidean distance to the nearest radiation therapy facility is a simplistic measure of estimating travel distance, and it does not take into account actual travel time or geographic barriers; calculation of an actual distance on a road network is more appropriate. The study included all radiation facilities that were present at the time of analysis (2006), and it is unclear whether all facilities were present during the study period (July 1997–December 2000).

A study conducted in the state of Virginia also aimed to determine whether higher mastectomy rates were associated with a greater distance to radiation therapy facilities (Schroen et al. [2005](#)). Women with invasive nonmetastatic adenocarcinoma of the breast were identified through the Virginia Cancer Registry from 1996 through 2000. Radiation facilities were identified through the cancer registry; the investigators confirmed the facilities were delivering breast radiation treatment during the study period. The distance from the centroid of each zip code in Virginia to the nearest radiation therapy facility was calculated as the straight-line distance. These distances were then linked by zip code to each patient. In total 20,094 patients with invasive breast cancer diagnosed during the 5-year study period were included in the study. Race, age, and tumor size varied with distance to the nearest radiation therapy facility. There was a relationship between increasing mastectomy rates and longer distances from the zip code centroid to the nearest radiation therapy facility, and this relationship was particularly evident in patients with T1 tumors. After controlling for patient age, race, year of diagnosis, extent of disease, and tumor size, distance to the nearest radiation therapy facility remained an independent predictor of mastectomy (Schroen et al. [2005](#)). Like the Florida study, this study also used straight-line calculations to determine the distance from the patient to the nearest radiation therapy facility, although the method of calculating this distance was slightly different. The actual travel distance in both studies is likely underestimated, particularly in mountainous regions. While the Florida study only included patients who underwent breast-conserving surgery with radiation, the Virginia study included all patients who underwent breast-conserving surgery and analyzed them together regardless of whether patients received radiation therapy or not. Among women who had breast-conserving surgery, 73 % underwent radiation therapy and 27 % had unknown radiation therapy status.

Geographic variation in cancer surgery can be assessed both by small-area variation analysis and by regional variation. Although small-area variation analysis is a valid way to study variation in cancer surgery, it is less commonly used than geographic regions, and more recently, the technique of geocoding has been used to help describe variations in cancer surgery.

System Comparisons

The definition of a health-care system is the organization of people, institutions, and resources to deliver health-care services to meet the health needs of a target population (World Health Organization [2013](#)). From an international perspective, the World Health Organization ranks health-care systems according to the overall level and distribution of health in the population. Although

direct comparisons of health statistics across countries are complex, international comparisons of health-care systems have been performed for many indices including life expectancy, infant mortality rate, physicians per 1,000 people, per capita expenditure on health, and health-care costs as a percent of GDP.

Studies that compare outcomes across health-care systems usually utilize routine health statistics such as cancer registries, vital statistics, and hospital episode data. The Veterans Health Administration [VHA] is a large health-care system in the United States that provides care to almost nine million veterans yearly. Prior to 1990 there was an impression that there was poor quality of care (including surgical care) within the system with long waiting periods and overuse of inpatient services (Keating et al. [2011](#)). This prompted a major restructuring of the system which emphasized primary care and quality measurement/reporting (Keating et al. [2011](#)). In a recent study (2011), cancer care provided in the VHA was compared to care provided to patients enrolled in fee-for-service Medicare (Keating et al. [2011](#)). VHA system cancer patients were identified from the Department of Veterans Affairs Central Cancer Registry; these data were linked to administrative data from the VHA and with the National Death Index. Patients treated in the private sector were identified from the SEER registry and linked to the Medicare data. Patients were included in the study if they were male and older than 65 years with a diagnosis of colorectal, lung, or prostate cancer between 2001 and 2004. Patients were excluded if the cancer was diagnosed at autopsy or by death certificate only, if data were incomplete, or if the patient had more than one primary cancer. Propensity score analysis (accounting for age, race, marital status, Charlson comorbidity score, history of cancer, census region, quarter-year of diagnosis, and socioeconomic variables for the zip code of the patients' residence) was used to account for sociodemographic differences between patients treated in the VHA and those treated in the fee-for-service Medicare system. Differences in quality measures between the systems were estimated, accounting for unequal weighting of observations and clustering at the health services area level. VHA patients and those treated in the private sector differed; VHA patients were younger, more likely to be African-American, and more likely to live in areas with lower education and income levels. Among patients with colorectal cancer, patients in the VHA were diagnosed at an earlier stage and were more likely to undergo resection for stage I, II, or III colon cancer than patients treated in the private sector (93 % vs. 90 %). There was no difference between the two systems in the proportion of patients with stage I, II, or III rectal cancer undergoing resection. Among patients with lung cancer, there were no significant differences in the proportion of patients who underwent curative surgery for stage I or II non-small cell lung cancer between the two US health-care systems. Overall, this study demonstrated that care for older men with colorectal and lung cancer diagnosed or treated in the VHA was similar to care provided in the private fee-for-service system.

International comparisons of practices for cancer surgery have also been performed, for example, trends in breast and axillary surgery in elderly patients with early stage breast cancer have been studied in a number of countries (Kiderlen et al. [2012](#)). In a study comparing breast cancer treatment in the Netherlands, Ireland, Switzerland, Belgium, Germany, Portugal, and the United States, women aged 65 or older with early stage breast cancer (T0-2, N0-1, M0) were identified from population-based cancer registries. Aggregate tables were created to compare the treatment percentages and survival between the countries. Breast surgery was categorized as mastectomy, breast-conserving surgery, or no surgery. Axillary surgery (sentinel node biopsy or axillary lymph node dissection) was recorded as yes/no. This study included a total of 204,885 patients across the seven countries. Significant variation in the proportion of women with breast cancer undergoing no surgery was found between the countries; however, this varied by age. Nearly all patients under age 75 underwent surgery with small but statistically significant differences among the countries. Differences in the use of breast surgery were larger for older women. In Ireland, more than 60 % of patients aged 90 or older did not undergo breast surgery for breast cancer. In contrast, in the United States, fewer than 10 % of

patients in the same age category did not undergo surgery. There was also significant variation in the use of axillary surgery among women of all ages with rates ranging from 1.4 % in Germany to 22.6 % in Ireland. This study used population-based data sets and included a large number of patients; however, there may be differences in data collection methods between the registries that participated in the study. In some countries included in the study, national cancer databases did not exist (only the Netherlands, Belgium, and Ireland have national cancer registries); therefore, regional data was used. Regional data may not be representative of the practice patterns within the entire country.

Furthermore, the years of available data were not the same for all countries (ranging from 1995 to 2008), and changes in practice patterns over time could change the findings of the study.

Many comparisons of countries or health systems are ecological studies which are epidemiologic studies where the unit of analysis is a population rather than an individual (Greenland and Morgenstern [1989](#)). A study of prostate cancer mortality in the United States and United Kingdom in 1975–2004 has been performed (Collin et al. [2008](#)). This study utilized data from cancer-mortality statistics from Cancer Research UK and from the US National Cancer Institute SEER program. The study found that age-specific and age-adjusted mortality was almost identical in the mid-1990s, but rates declined substantially in the United States after 1994. The authors showed that the proportion of men with prostate cancer who underwent radical prostatectomy in the United States increased dramatically from the mid-1980s and reached a plateau in the mid-1990s with approximately 30 % of all patients with prostate cancer undergoing a radical procedure. In the United Kingdom, the proportion of patients with prostate cancer who underwent a radical procedure was substantially less. In 2004, approximately 10 % of prostate cancer patients underwent radical prostatectomy. This data is difficult to interpret as patient age is not taken into account when the radical surgical treatment was considered at the stage of the cancer was not considered in either the mortality rates or in the proportion of patients undergoing radical prostatectomy.

Ecologic data are often readily available at low cost, and studies using these data may generate etiological hypotheses and are important when examining trends of disease over time and place. However, there are several weaknesses to be aware of when interpreting studies utilizing ecologic data, including lack of completeness of the data with potential bias and variation in data collection methods across geographic regions (particularly if multiple countries or continents are involved), and equivalent data may not be available for all countries. One of the major limitations of ecological studies is ecological fallacy – an incorrect inference made about an individual based on aggregate data for a group. For example, if a study showed that countries with higher rates of coffee consumption had lower rates of cancer, then it would be an ecological fallacy to conclude that drinking coffee would reduce the risk of cancer. This fallacy can arise from three sources of bias: within-group bias, confounding by group, and effect modification by the group (Greenland and Morgenstern [1989](#)). Within-group bias occurs if the exposure within groups varies by confounding, selection methods, or misclassification. For example, if a country's coffee consumption was estimated by determining coffee production, this would be an error because coffee is often exported and not consumed in the country it is produced in. Confounding might occur if the background rate of disease in the unexposed population varies across groups (Greenland and Morgenstern [1989](#)). An example of confounding by group is if the rate of cancer was different in people who do not drink any coffee. Effect modification by group refers to variation in the rate of the exposure across the groups. For example, if there was a small proportion of the population in country A who consumed a large amount of coffee and in country B a large proportion of the country consumes a small amount of coffee, the coffee consumption among the two countries may be the same. Controlling for confounders and other covariates will not always remove these biases (Greenland and Morgenstern [1989](#)). A strategy for

reducing ecological fallacy is to make the groups more homogeneous by using smaller units in an ecological study (e.g., comparing counties instead of states).

Volume-Outcome Studies

It is commonly believed that performing higher volumes of surgical procedures improves the technical proficiency of those performing the procedures and should result in improved outcomes for patients. Many studies across a variety of cancers (breast, lung, esophageal, colorectal, pancreas, liver, thyroid) have been performed to evaluate the effect of hospital volume (Birkmeyer et al. [2002](#)), hospital type (Elferink et al. [2010](#)), surgeon volume (Birkmeyer et al. [2003](#)), and surgeon specialization (Porter et al. [1998](#)) on oncologic outcomes. Almost uniformly these studies show at least a modest improvement on patient outcomes with increasing volume and specialization. Two main hypotheses have been proposed to explain this relationship (Luft et al. [1987](#)). Surgeons and hospitals that treat high volumes of specific patients may develop greater skills resulting in improved outcomes, the “practice makes perfect” hypothesis. “Selective referral” is where surgeons and hospitals with better outcomes attract more patients and is an alternative hypothesis.

A landmark study evaluating the volume-outcome relationship was published in the *New England Journal of Medicine* in 2002 (Birkmeyer et al. [2002](#)). This study looked at the association between hospital volume and postoperative mortality across a number of cancer (and non-cancer) operations using the Medicare database and suggested that higher-volume hospitals have lower mortality rates for a number of major cancer resection types (Birkmeyer et al. [2002](#)). Patients who underwent one of the 14 procedures examined were identified from the Medicare database for the years 1994–1999 using procedure codes from the ICD-9. Patients were excluded if they were under age 65 or older than 99 years of age. The 14 procedures included were coronary-artery bypass grafting, heart valve replacement (mitral and aortic), carotid endarterectomy, lower extremity bypass, elective abdominal aortic aneurysm repair, colectomy, gastrectomy, esophagectomy, pancreatic resection, nephrectomy, cystectomy, and pulmonary resection (pneumonectomy, lobectomy). The average number of procedures per year (hospital volume) was determined for each of the procedures for all hospitals providing care. Hospital volume was categorized to simplify the presentation of results into five volume categories: very low, low, medium, high, and very high. Hospitals were rank ordered for hospital volume for each procedure and then were divided based on whole-number quintiles for the number of patients treated. The primary outcome variable was mortality before hospital discharge or within 30 days of the index hospital procedure. Multivariate logistic regression was used to examine the relationship between hospital volume and operative mortality with adjustments for patient factors and accounting for clustering within hospitals using over-dispersed binary logistic regression models. Over the 5-year study period, 2.5 million patients underwent one of the 14 procedures examined in this study. The criteria used to define hospital volume varied according to the procedure. For example, a very high-volume hospital performed >849 coronary-artery bypass grafts per year; in contrast, a hospital performing >11 cystectomies per year was considered very high volume. In general higher-volume hospitals had lower operative mortality rates for the eight types of major cancer resections examined in this study. The magnitude of the relation between volume and outcome varied according to the procedure. The improved outcomes appear to be especially pronounced in the resection of complex cancers such as pancreas and esophagus. For example, the adjusted odds ratio for mortality after nephrectomy at a very high-volume hospital was 0.80 (95 % CI 0.68–0.95) compared to treatment in a very low-volume hospital indicating a slightly lower risk of mortality at a high-volume hospital. In contrast, the adjusted odds ratio for pancreatic resection at a very high-volume hospital was 0.20 (95 % CI 0.14–0.29) indicating a much lower risk of mortality at a high-volume hospital.

Subsequently, the authors performed another study aimed at eliciting whether the increased mortality at low-volume centers was due to higher complication rates or less success in rescuing patients from their complications (Ghaferi et al. [2011](#)). Using similar methods described above, the authors compared the incidence of major complications and case fatality among patients with complications across hospital volume quintiles for three high-risk cancer operations: gastrectomy, pancreatectomy, and esophagectomy. Overall, they found that patients who underwent these high-risk operations in very low-volume hospitals had only slightly higher complication rates (OR 1.17, 95 % CI 1.02–1.33), but patients were much more likely to die once the complications had occurred (OR 2.89, 95 % CI 2.40–3.48) compared to patients treated in very high-volume hospitals.

The analyses performed in these studies have some limitations. Hospital volume was estimated by extrapolating from Medicare volume, and there likely is some degree of misclassification of hospital volume status. Additionally, case mix (types of patients grouped according to comorbidities, severity of disease, etc.) may not have been adequately accounted for because of the nature of administrative databases. Emergency cases were included, and there were increased numbers of emergency cancer surgeries performed in lower-volume hospitals.

Because a number of surgeons may perform a given procedure at a hospital, surgeon volume may confound the relationship between hospital volume and outcome. The impact of surgeon volume on the relationship between hospital volume and patient outcome has been investigated (Birkmeyer et al. [2003](#)). Patients who underwent one of the eight procedures (coronary-artery bypass grafting, aortic heart valve replacement, carotid endarterectomy, elective abdominal aortic aneurysm repair, esophagectomy, pancreatic resection, cystectomy, and pulmonary resection (pneumonectomy, lobectomy)) examined were identified from the Medicare database for the years 1998–1999 using ICD-9 procedure codes. Patients were excluded if they were under age 65 or older than 99 years of age. Surgeon and hospital volume were characterized by determining the average number of procedures performed in each hospital by each surgeon on Medicare patients, adjusted to approximate procedure volume for patients of all ages using the 1997 Nationwide Inpatient Sample. The proportion of patients undergoing each procedure in the Medicare database was determined. Each provider's observed Medicare volume was divided by the procedure-specific proportion. Categorical volume variables were created by rank-ordering providers and patients into three evenly sized groups (for hospitals and surgeons separately). Multivariate logistic regression analysis was used to examine the relationship between surgeon volume and operative mortality. Adjustment was made for patient characteristics and hospital volume. The effect of clustering of patients within surgeons and clustering of surgeons within hospitals was accounted for using mixed-effects models. Overall 474,108 patients were included in the study. Patients were more likely to undergo surgery by a low-volume surgeon if they went to a low-volume hospital. The strength of the relationship between surgeon volume and operative mortality varied according to the procedure. For example, the odds ratio for death in patients undergoing lung resection was 1.24 (95 % CI 1.08–1.44) for patients treated by a low-volume surgeon compared to a high-volume surgeon. For patients undergoing pancreatic resection, the odds ratio of death was 3.61 (95 % CI 2.44–5.33) for patients treated by a low-volume surgeon. When hospital volume was added into the multivariate analysis, the strength of the association between surgeon volume and operative mortality decreased. In patients undergoing esophagectomy, the odds ratio for death was 2.30 (95 % CI 1.54–3.42) for patients treated by low-volume surgeons, which decreased to 1.80 (95 % CI 1.13–2.87) after accounting for hospital volume in addition to surgeon volume. Factors related to both surgeon volume and hospital volume likely contribute to the relationship between volume and outcome for high-risk procedures. For example, in the management of lung cancer, treatment by a high-volume surgeon may ensure a high-quality oncologic procedure and appropriate

referral for adjuvant therapies, but hospital-based services are important in this type of patient as their postoperative courses may be prolonged and susceptible to serious postoperative complications. Surgeon volume also impacts the choice of surgical procedure for several types of cancer (Abouassaly et al. [2012](#); Martling et al. [2002](#); Richardson et al. [2013](#)). The level of knowledge pertaining to cancer care may differ between high- and low-volume surgeons. The impact of surgeon knowledge on the relationship between surgeon volume and patient outcome was investigated in patients with rectal cancer (Richardson et al. [2013](#)). Patients with a new diagnosis of rectal cancer over a 5-year period were identified from a Canadian cancer registry, and a comprehensive review of hospital inpatient and outpatient medical records was performed. Surgeon knowledge was assessed by a mail questionnaire sent to all practicing general surgeons in Nova Scotia. The questions were developed so that responses could be scored as “appropriate” or “inappropriate,” and surgeons were given one point for each “appropriate” response, with a maximum possible score of 8. Patients from the population-based cohort who received treatment from survey respondents were identified. The association between surgeon volume and patient outcomes was evaluated using multivariate techniques. To examine the impact of surgeon knowledge, the surgeon survey score was added into the multivariate model. Overall 25 survey respondents treated 377 patients with rectal cancer. Patients treated by a high-volume surgeon were less likely to receive a permanent colostomy (OR 0.53, 95 % CI 0.30–0.93) and more likely to undergo TME (OR 3.59, 95 % CI 2.21–5.83). Surgeon knowledge was associated with lower use of permanent colostomy (OR 0.49, 95 % CI 0.25–0.97), and the relationship between surgeon volume and use of permanent colostomy was diminished (OR 0.84, 95 % CI 0.41–1.70) after adjusting for the effect of surgeon knowledge. There was a significant interaction between higher surgeon procedure volume and surgeons’ use of TME. These data suggest that there may be a relationship between surgeon knowledge and patient outcomes in rectal cancer, and this relationship may at least partly explain the surgeon volume-outcome relationship.

The literature evaluating volume-outcome relationships in cancer surgery has limitations. Categorization of volume thresholds is a major issue in interpreting volume-outcome relationships. Thresholds that determine high and low volume are heterogeneous. In most cases they are chosen empirically for an individual study using volume distribution to define the cut points dividing the group into tertiles, quartiles, or quintiles. Comparisons are then typically made between the highest and lowest groups. Alternative methods of determining cut points, such as a hypothesis-driven approach based on the complexity of the case, the learning curve requirement, or the number of cases needed to maintain expertise, are rarely used. This results in variation in the definition of high volume for different procedures and for the same procedure between different studies. For example, in the Birkmeyer et al. ([2002](#)) study discussed above, a hospital was considered to be very high volume if it performed greater than 124 colon resections. However, to be considered very high volume in esophagectomy, a hospital need only perform greater than 19 procedures.

Differences in case mix between high- and low-volume hospitals may occur. While risk adjustment of data in administrative database analyses is intended to reduce the effect of confounding due to baseline differences in patient groups (Birkmeyer et al. [2002](#), [2003](#)), it is possible that these factors do not adequately account for variation in case mix and that patients with higher preoperative risk factors (e.g., emergency cases) are being managed in low-volume hospitals which would bias results toward finding improved outcomes at high-volume centers. To determine if risk adjustment using prospective data and clinical variables was superior to risk adjustment performed on administrative data sets, patients who underwent carotid endarterectomy (CEA) from 2008 to 2010 were evaluated preoperatively, 24 h postoperatively, and 30 days postoperatively (Maas et al. [2013](#)). Patient-level data including risk factors for stroke, modified Rankin Scale score, ASA class, preoperative symptoms, National Institutes of Health Stroke Scale (NIHSS) score, degree of arterial stenosis and

degree of contralateral stenosis, and whether the procedure was elective or emergent were prospectively recorded. For consistency surgeon volume categories were set at the same level as the previously discussed administrative-level study by Birkmeyer et al. ([2003](#)). Overall 841 cases of CEA were included in the study. Two multivariate analyses were performed: the first analysis adjusted for the same administrative data variables as Birkmeyer et al. ([2003](#)). Consistent with that study, the adjusted odds ratio for stroke and death for low-volume surgeons was 3.61 (95 % CI 1.72–7.89). A second multivariate analysis was performed which controlled for clinical variables including stroke as a symptomatic indication, ASA class, preoperative modified Rankin Scale score, and preoperative NHISS score. In this analysis the adjusted odds ratio for stroke and death in patients treated by low-volume surgeons as compared to high-volume surgeons was not statistically significant (OR 1.42, 95 % CI 0.72–2.82). The results of this study suggest that case mix may differ between low-volume and high-volume surgeons. Risk adjustment in administrative-level studies may have led to overestimation of the impact of surgeon volume on patient outcomes.

Many studies evaluating the relationship between surgical volume and outcome have additional methodological problems. Initial volume-outcome studies used simplistic single-level multivariable regression models to evaluate the relationship. However there is clustering of patients who are treated by individual surgeons and of surgeons within institutions resulting in correlation of individuals who are nested in higher level units (surgeon, hospital). Hierarchical modeling is an analytical approach that allows the simultaneous examination of group-level and individual-level variables on individual-level outcomes (Diez-Roux [2000](#)). When conventional and multilevel models were used to simultaneously estimate surgeon and hospital volume-outcome effects for surgical procedures, the conclusions based on the analysis were determined by the statistical method used (Urbach and Austin [2005](#)). Using conventional models the overall risk of death within 30 days of surgery was significantly lower in patients treated in high-volume hospitals and by high-volume surgeons compared to those treated in low-volume hospitals or by low-volume surgeons. However, when multilevel analysis was performed, the confidence intervals were wider, and statistically significant results were not present in most of the models examined (Urbach and Austin [2005](#)). There is consensus that multilevel modeling is the most appropriate method of estimating institution and surgeon performance. This has broad implications for the interpretation of the volume-outcome literature; although there have been substantial improvements in the volume-outcome literature over time, many studies have not used appropriate statistical methods.

Despite the limitations of the volume-outcome literature, patients and payers have been encouraged to select hospitals that meet minimum volume standards for elective surgical cases to achieve optimal patient outcomes (Birkmeyer et al. [2002](#), [2003](#)). Many object to these types of initiatives because procedure volume is not always a perfect proxy for good quality; there are many low-volume hospitals that may provide excellent care with good outcomes (Birkmeyer et al. [2002](#)). Additionally the true volume threshold required to achieve optimal outcomes has not been determined.

Disparities

Health disparities are differences in the incidence, prevalence, mortality, and burden of disease among specific populations (Keppel et al. [2005](#)). These populations are typically characterized by gender, sex, age, ethnicity, race, education, income, social class, disability, or sexual orientation. The goal of health disparities research is to describe disparities and associated characteristics and develop efficacious and effective interventions to reduce disparities.

Socioeconomic status (SES) has been associated with disparities in cancer surgery. SES can be measured in several ways including educational achievement, occupational characteristics, income,

living conditions, health insurance, or residence in geographic areas with particular social or economic conditions. Summary measures of SES have been created using the US Medicare database. Data on income, education, and occupation from the US census can be linked to the patient's zip code of residence from the Medicare files. For many years an inverse relationship between SES and cancer survival has been reported, and recent studies have investigated variations in cancer treatment according to SES. The impact of SES on treatment delay time and survival has been examined in young women with breast cancer (Smith et al. [2013](#)). The study included adolescent and young adult patients aged 15–39 years with breast cancer diagnosed in California from 1997 to 2006 using the California Cancer Registry database. Treatment delay time was based on the number of weeks between the date of diagnosis and the date the patient underwent definitive treatment (surgery or neoadjuvant chemotherapy). The treatment delay time was classified into four groups: less than 2 weeks, 2–4 weeks, 4–6 weeks, and more than 6 weeks. SES was a single variable created from a component analysis of census block group-level data that included: educational attainment, household income, proportion below 200 % of the poverty level, house value, rent, percentage employed, and proportion with blue-collar employment. SES was then categorized into quintiles. The study included 8,860 adolescent and young adult patients with breast cancer. The mean time delay to treatment was 2.7 weeks and this varied significantly according to race, SES, insurance status, and stage. Hispanic and African-American patients were more likely than white patients to wait more than 6 weeks for treatment (15.3 %, 15.3 %, and 8.1 %, respectively). Patients in the lowest SES quintile were more likely to wait longer than 6 weeks for treatment compared to patients in the highest SES quintile (17.5 % vs. 7.7 %); patients with no insurance or public insurance were more likely than patients with private insurance to wait longer than 6 weeks for treatment (17.8 % vs. 9.5 %). Patients who had a treatment delay longer than 6 weeks had worse 5-year survival (78 %) compared to patients who started treatment within 2 weeks (84 %). Among patients with treatment delay time greater than 6 weeks, patients with low SES had worse 5-year survival than patients with high SES (69 % vs. 82 %, respectively). On multivariate analysis both SES and treatment delay time were independent risk factors for death after controlling for race, age, year of diagnosis, insurance status, stage, and estrogen receptor status. Patients who were in the lowest SES group had a higher risk of death than patients in the highest SES group (HR 1.66, 95 % CI 1.25–2.20), and patients with treatment delay time greater than 6 weeks had increased risk of death than patients who received treatment earlier (HR 1.82, 95 % CI 1.21–2.74). The results of this study suggest that patients with breast cancer in low SES groups have treatment delays in the management of their cancer, and this may result in worse overall survival.

Race had been linked to differences in the treatment of cancer using administrative databases; black patients in the United States may be less likely to undergo definitive locoregional cancer care (Freedman et al. [2011](#)) and in some studies were less likely to undergo any surgical resection for cancer (Esnaola et al. [2008](#); Hodgson et al. [2001](#)). However not all US studies have found differences in the surgical management of cancer patients based on race (Alderman et al. [2011](#)). The observed variations in surgical treatment based on race and ethnicity could be related to differences in severity of disease, comorbid illness, access to care, racial discrimination, or patient attitudes and preferences. Racial and ethnic differences in practice patterns and outcomes may occur because of the use of different providers or different treatments by the same providers. The effect of ethnicity/race on the use of high-volume surgeons at high-volume hospitals was examined for patients with breast, colorectal, gastric, lung, and pancreatic cancer (Epstein et al. [2010](#)). Patients in New York City who underwent surgery for breast, colorectal, gastric, lung, or pancreatic cancer between 2001 and 2004 were included. Ethnicity/race was categorized as white, black, Asian, and Hispanic. Median case volume was used to categorize volume as high or low, and multivariate logistic regression models

were used to assess the association of race/ethnicity on the use of high-volume surgeons and hospitals. Clustering of patients in residential zip codes was accounted for in the analysis. White patients were more likely to be treated by high-volume surgeons and in high-volume hospitals. After adjusting for demographic, SES, and insurance characteristics, the combined use of high-volume providers was significantly lower among black, Asian, and Hispanic patients as compared to white patients. For example, in the management of pancreatic cancer, the adjusted rate of surgery by high-volume surgeons in high-volume hospitals was 17 percentage points lower in black patients compared to white patients. Overall, the results of this study suggest that black patients appear to be less likely to access care at high-volume hospitals or by high-volume surgeons compared to white patients (Epstein et al. [2010](#)). This suggests that some of the racial disparities in outcome may be due to modifiable factors (the location of care and volume of care providers), and changes in the way care is provided may result in improved outcomes among black, Asian, and Hispanic patients.

There are some general limitations to studies of disparities that should be considered (Keppel et al. [2005](#)). The way that disparity is measured affects the size and direction of the effect. The choice of the reference category will determine both the size and direction of the disparity. It is usually measured from the group with the best outcome in order to emphasize the potential for improvement. Disparity can be measured in absolute or relative terms; ideally both are measured in order to better understand the magnitude of the disparity.

Despite the recognition of inequalities in the treatment of cancer based on race, ethnicity, and SES, these problems remain, and the reasons underlying the inequalities are unclear. A better understanding of social factors other than SES is required to fully comprehend disparities in care. Patient factors such as difficulties in accessing health services, mistrust of the health-care system, and differing preferences may be important. While much of the health services research in cancer care has focused on identifying variations and disparities in care, relatively little work has focused on how to minimize the disparities that currently exist.

Case Study of Cancer Care in Canada

The remainder of the chapter will focus on case studies illustrating cancer care in Canada. The case study describes the surgical management of breast cancer and highlights variation in cancer surgery according to geographic location.

Variations in the Surgical Management of Breast Cancer

In Canada breast cancer is the most common cancer affecting women and the second leading cause of cancer deaths. In 2013, 24,000 women will be diagnosed with breast cancer; 5,100 will die from the disease (Statistics [2013](#)). Breast cancer can be identified by the woman herself, during clinical breast exam or with mammography. In order to diagnose the cancer, a biopsy (needle or surgical) is generally performed to sample cells for examination by the pathologist. Patients typically undergo surgery to remove the tumor if cancer is confirmed. In Canada, breast cancer surgery can be performed either by general surgeons or surgical oncologists.

Several procedures exist for the management of breast cancer, and the specific procedure that is most appropriate for a given patient will be determined by various factors including the woman's age, comorbidities, breast size, tumor size, and lymph node status. *The first surgical decision is whether to perform mastectomy or breast-conserving surgery.* In the surgical management of early stage breast cancer, many patients have the option of undergoing either a mastectomy or breast-conserving surgery

followed by radiation therapy. In randomized controlled trials, patients who undergo either of these options have similar overall survival (Early Breast Cancer Trialists' Collaborative Group [1995](#)). Cancer Care Ontario has published evidence-based guidelines that recommend that women who are eligible for breast conservation therapy should be offered the choice of either breast-conserving surgery or mastectomy (Brackstone et al. [2011](#)). Patients who undergo mastectomy may wish to undergo subsequent breast reconstruction using either an implant or a flap procedure. The second surgical decision is whether to sample axillary lymph nodes. To properly stage the patients' cancer, the lymph nodes should be sampled. There are two methods of sampling the lymph nodes: axillary dissection and sentinel lymph node biopsy. If the sentinel node tests positive for breast cancer, the patient usually has a completion axillary dissection. Following surgery, patients may require other therapies such as radiation therapy, chemotherapy, or hormone therapy. Ideally breast cancer is managed in a multidisciplinary setting as the management of breast cancer requires different types of physicians.

The purpose of this case study is to describe the management of breast cancer in a Canadian province. Variations in surgical care were examined according to geographic region, surgeon specialty, and hospital type. Disparities in surgical care according to age, neighborhood income quintile, and community size were also studied.

As part of an Institute for Clinical Evaluative Sciences surgical care atlas, the treatment delivered to Ontario women 20 years of age or older with invasive breast cancer who were diagnosed with the disease between April 1, 2003, and March 31, 2004, was described (Quan et al. [2008](#)). The patients were identified from the Ontario Cancer Registry. Small-area analysis comparisons of cancer care were made across Local Health Integration Networks (LHINs) which are the health authorities that administer health care regionally including hospital care, community care access centers, community support services, long-term care, mental health and addiction services, and community health centers in Ontario.

During the study period the breast cancer incidence rate was 146 cases per 100,000 women 20 years of age or older (range: 131 cases per 100,000 to 163 cases per 100,000). Just over half of incident cases (52 %) occurred in women over 60 years of age and 92 % of women diagnosed with breast cancer underwent surgery within 12 months of their diagnosis and 52 % of patients' surgical procedures were done as outpatient same-day surgery. The rate of outpatient surgery varied by the LHIN and rates ranged from 36 % to 73 %. There were no disparities in the surgical management of breast cancer according to neighborhood income or community size. However, older patients (70 years or older) were slightly less likely to undergo a surgical procedure compared to younger patients (86 % vs. 92 %). Local and distant diagnostic testing was utilized in nearly all patients with breast cancer during the study period. However in this study cohort diagnostic imaging tests may have been overutilized. Staging guidelines for women with breast cancer recommend evaluation of distant sites of disease for metastases in high-risk patients only; however in this cohort up to 80 % of patients had evaluation of distant disease sites. In reality a much smaller proportion of patients would be expected to be high risk and therefore candidates for such diagnostic imaging tests.

A majority of women in Ontario who underwent surgery for invasive breast cancer had breast-conserving surgery (61 %) and a lymph node excision procedure (76 %). There was variation in the type of surgery performed according to LHIN, with breast-conserving surgery rates ranging from 46 % to 75 % and lymph node sampling rates ranging from 70 % to 86 % (Table [1](#)). There was little variation in the type of surgery performed (breast-conserving surgery vs. mastectomy) according to different surgeon groups (general surgeons, breast surgeons, surgical oncologists) or hospital types (academic vs. community, Table [2](#)). Variations in the choice of surgery for breast cancer are unknown

but might be explained by differences in the stage of the cancer at the time of diagnosis, patient or surgeon preferences, or resource availability. **Table 1**

Type of definitive surgical procedure among women in the breast cancer surgery cohort by age, income quintile, community size, and LHIN of patient residence in Ontario

Characteristic	Breast cancer surgery cohort number	Definitive procedure number (%)				
		Breast-conserving surgery only	Breast-conserving surgery and lymph node excision	Mastectomy	Mastectomy and lymph node excision	Other
Ontario	6,548	849 (13.2)	3,175 (48.1)	702 (10.8)	1,777 (27.2)	45 (0.7)
Age group (years)						
20–39	**	** (6.6)	** (47.5)	** (13.2)	** (31.7)	**
40–49	1,218	98 (8.0)	656 (53.9)	139 (11.4)	317 (26.0)	8 (0.7)
50–59	1,629	150 (9.2)	919 (56.4)	146 (9.0)	396 (24.3)	18 (1.1)
60–69	1,495	150 (10.0)	801 (53.6)	140 (9.4)	394 (26.4)	10 (0.7)
70+	**	** (23.3)	** (33.9)	** (12.4)	** (30.1)	**
Neighborhood income quintile						
Q1 (lowest)	1,129	161 (13.6)	489 (44.0)	124 (10.7)	347 (30.9)	8 (0.7)
Q2	1,233	168 (13.6)	581 (47.0)	129 (10.6)	347 (28.1)	8 (0.6)

Q3	1,295	153 (12.0)	629 (48.4)	133 (10.3)	373 (26.8)	7 (0.5)
Q4	1,337	176 (14.1)	691 (50.5)	141 (10.6)	319 (24.1)	10 (0.7)
Q5 (highest)	1,376	168 (13.2)	694 (49.2)	154 (11.3)	349 (25.6)	11 (0.7)
Community size (population)						
≥1,250,000	2,497	366 (15.6)	1,346 (53.1)	276 (10.9)	485 (19.4)	24 (0.9)
100,000– 1,249,999	2,496	306 (12.2)	1,120 (44.8)	240 (9.7)	819 (32.9)	11 (0.4)
<100,000	1,554	177 (10.9)	708 (46.1)	186 (11.9)	473 (30.5)	10 (0.6)
LHIN						
1. Erie St. Clair	**	** (6.9)	** (39.4)	** (10.5)	** (41.9)	**
2. South West	**	** (69.4)	** (41.8)	** (14.2)	** (34.4)	**
3. Waterloo Wellington	**	** (10.5)	** (44.9)	** (13.2)	** (30.7)	**
4. Hamilton Niagara Haldimand Brant	**	** (18.8)	** (48.2)	** (9.1)	** (23.2)	**
5. Central West	**	** (16.2)	** (53.7)	** (11.1)	** (18.1)	**
6. Mississauga Halton	**	** (12.2)	** (62.7)	** (9.4)	** (15.0)	**
7. Toronto Central	615	95 (16.7)	305 (48.5)	82 (13.2)	127 (20.7)	6 (1.0)

8. Central	753	122 (16.7)	387 (51.4)	86 (11.4)	149 (19.4)	9 (1.1) **
9. Central East	**	** (14.1)	** (49.6)	** (8.4)	** (27.3)	**
10. South East	**	** (11.7)	** (55.0)	** (9.0)	** (23.5)	**
11. Champlain	**	** (8.2)	** (44.6)	** (5.8)	** (41.1)	**
12. North Simcoe Muskoka	**	** (11.4)	** (48.5)	** (15.4)	** (24.0)	**
13. North East	**	** (10.4)	** (40.7)	** (14.2)	** (34.4)	**
14. North West	124	13 (10.0)	52 (42.1)	14 (11.1)	45 (36.8)	0 (0.0)

**Cell value suppressed and removed from totals for reasons of privacy and confidentiality

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Data sources: Canadian Institute for Health Information (CIHI), Ontario Health Insurance Plan (OHIP), Ontario Cancer Registry (OCR), and Registered Persons Database (RPDB)

Table 2

Type of surgical procedure for women in the breast cancer surgery cohort according to physician specialty and hospital type

				Definitive procedure number (%) of patients				
	Physicians performing breast cancer surgery number	All breast cancer surgeries number (% surgeries)	Total patients number (% patients)	Breast-conserving surgery only	Breast-conserving surgery and lymph node excision	Mastectomy	Mastectomy and lymph node excision	Other

	ber (% physi cians))						
Physi cian specia lty								
Gener al surge ons with self- identi fied breast subsp ecialt y	25 (5.4)	1,368 (16.6)	1,080 (17.2)	179 (16.6)	496 (45.9)	161 (14.9)	235 (21.8)	9 (0. 8)
Gener al surge ons with self- identi fied surgic al oncol ogy subsp ecialt y	14 (3.0)	420 (5.1)	356 (5.7)	37 (10.3)	182 (50.8)	34 (9.5)	103 (28.8)	**
Gener al surge ons with no self- identi fied subsp ecialt y	307 (65.7)	5,683 (68.8)	4,360 (69.3)	526 (12.1)	2,120 (48.6)	448 (10.3)	1,237 (28.3)	30 (0. 7)

Other	121 (25.9)	791 (9.5)	488 (7.8)	66 (13.5)	244 (49.8)	36 (7.3)	142 (29.0)	**
Hospital type								
Academic	14 (10.9)	2,300 (27.0)	1,983 (29.6)	273 (14.1)	938 (48.4)	218 (11.3)	500 (25.8)	9 (0.5)
Community	114 (89.1)	6,229 (73.0)	4,608 (70.4)	574 (12.5)	2,237 (48.5)	484 (10.5)	1,277 (27.7)	36 (0.8)

**Cell value suppressed and removed from totals for reasons of privacy and confidentiality

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Data sources: Canadian Institute for Health Information (*CIHI*), Ontario Health Insurance Plan (*OHIP*), Ontario Cancer Registry (*OCR*), Registered Persons Database (*RPDB*), ICES Physician Database (*IPDB*), and the Canadian Medical Directory (*CMD*)

Breast cancer management ideally takes place in a setting where multidisciplinary services and care by surgeons, radiation oncologists, and medical oncologists can be provided. Overall, 75 % of women who underwent surgery for invasive breast cancer saw a radiation oncologist postoperatively, and 65 % of patients received radiation therapy planning. These findings suggest that access to radiotherapy services was adequate given that overall 61 % of women underwent breast-conserving surgery. Just under half of the patients undergoing surgery (44 %) saw a medical oncologist postoperatively. It is possible that a lower proportion of patients were assessed by medical oncology because surgeons did not feel adjuvant therapy was appropriate for these patients, surgeons treated the patients themselves (i.e., with hormonal therapies), or the patients may not have wanted referral to medical oncology. Small-area analysis by LHIN revealed that variations in practice patterns for breast cancer surgery exist in Ontario. There was no variation in surgical care according to surgeon subspecialty or hospital type. The impact of surgeon volume on surgical procedure choice was not assessed in this study. Disparities in care were not identified for neighborhood income quintile or community size. Older patients may be less likely to undergo a surgical procedure for breast cancer compared to younger patients. There are no obvious explanations for the observed variations. It is possible that access to radiation therapy prevented patients in some LHINs from undergoing breast-conserving surgery. More research is needed to understand variations in practice and quality gaps; a better understanding of the structure and process of care within the LHINs could lead to the identification of modifiable factors that could be optimized in an effort to eliminate variations and gaps in the care of patients with breast cancer. Most of the surgical procedures in this cohort of patients took place in community hospitals by general surgeons. Therefore, any planned interventions to improve breast cancer care at a population level must be targeted toward both general surgeons and subspecialists practicing in both community and academic hospitals.

Conclusion

There are many descriptions of variation in cancer surgery in the literature. This literature can be broadly classified as time trends, geographic areas, system comparisons, volume-outcome studies, and disparities. Each of these methods of describing variations in cancer surgery has limitations. Once variations in cancer surgery have been detected, the next step is to determine the impact of the variations on patient outcomes. If variations in patient outcomes also exist, then efforts should be made to standardize the surgical approach. These efforts should be applied to all surgeons providing care to patients with cancer regardless if they practice in community or academic centers.

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