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Analytical Studies: Methods and References

Canadian Cancer Treatment Linkage Project

by Gisèle Carrière, Claudia Sanmartin, Patricia Murison, Richard Trudeau, Cathy Trainor, Caroline Pelletier, Nathan Farrar, Austin Snow, Shirley Bryan and Kim Newman

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^{p} preliminary
^{r} revised
x suppressed to meet the confidentiality requirements of the *Statistics Act*
^{E} use with caution
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* significantly different from reference category ($p < 0.05$)

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Papers in this series provide background discussions of the methods used to develop data for economic, health, and social analytical studies at Statistics Canada. They are intended to provide readers with information on the statistical methods, standards and definitions used to develop databases for research purposes. All papers in this series have undergone peer and institutional review to ensure that they conform to Statistics Canada's mandate and adhere to generally accepted standards of good professional practice.

The papers can be downloaded free at www.statcan.gc.ca.

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Executive summary

Record linkage has been identified as a potential mechanism to add treatment information to the Canadian Cancer Registry (CCR). The purpose of the Canadian Cancer Treatment Linkage Project (CCTLP) pilot is to add surgical treatment data to the CCR. The Discharge Abstract Database (DAD) and the National Ambulatory Care Reporting System (NACRS) were linked to the CCR, and surgical treatment data were extracted. The project was funded through the Cancer Data Development Initiative (CDDI) of the Canadian Partnership Against Cancer (CPAC).

The CCTLP was developed as a feasibility study in which patient records from the CCR would be linked to surgical treatment records in the DAD and NACRS databases, maintained by the Canadian Institute for Health Information. The target cohort to whom surgical treatment data would be linked was patients aged 19 or older registered on the CCR (2010 through 2012) with a primary diagnosis of the following: female breast, colorectal, prostate, thyroid, urinary bladder, or lung cancer. To identify primary surgical treatments for these cancers, code sets were developed for each site using current standards (for example, Canadian Classification of Health Interventions [CCI]). With this linkage, two new core data elements were developed and added to the linked CCR-DAD-NACRS analytical file: *Procedure date* and *Primary procedure*.

The linkage was completed in Statistics Canada's Social Data Linkage Environment (SDLE). Within the SDLE, each file (CCR, DAD, NACRS) was linked to the Derived Record Depository (DRD), a regularly updated repository of personal identifiers for all Canadians. Linkage keys extracted through this process were used to create the linked CCR–DAD–NACRS file, from which the cohort was extracted (records with only one tumour from among the six target cancers coupled with surgical interventions identified in the treatment code set). Linkage rates for the three files were robust, with each having a rate greater than 90% in the years covered.

The CCTLP demonstrated the feasibility of using record linkage to add surgical treatment data to patient records for six cancers. Opportunities for further development were identified, including the need to improve linkage rates to minimize the number of surgical treatments that are lost. In addition, a protocol for assigning one or more surgical treatments to patient records where multiple tumours are present in the same organ, within the follow-up period, will be required. Nevertheless, record linkage has been shown to be an effective means of increasing the analytical value of Canadian cancer data holdings.

1 Introduction

The Canadian Cancer Registry (CCR), established in 1992, is a collaborative undertaking between Statistics Canada and the 13 provincial and territorial cancer registries to create a single database to report annually on cancer incidence and survival at the national and jurisdictional levels (Statistics Canada n.d.*b*, 2011). The Registry produces high-quality information on cancer events, but lacks information about treatment. The addition of treatment information would enhance the CCR's surveillance capacity and its analytical capacity for researchers and epidemiologists.

To address this information gap, Statistics Canada, in partnership with the Canadian Council of Cancer Registries (CCCR), undertook a study to determine the feasibility of using record linkage to add treatment information to the CCR for three cancers—breast, prostate and colorectal—in four provinces (Ontario, Manitoba, Nova Scotia, and Prince Edward Island). The study involved linking hospital data (Discharge Abstract Database [DAD] and National Ambulatory Care Reporting System [NACRS]) to the CCR. The results demonstrated the feasibility of using record linkage to add treatment data to the CCR, specifically, surgical treatment data, which are comprehensively reported in the hospital data (Carrière et al. 2015).

The Canadian Cancer Treatment Linkage Project (CCTLP) builds on that work. Using the Social Data Linkage Environment (SDLE) at Statistics Canada, the DAD and the NACRS were linked, and administrative, diagnostic and surgical treatment data were extracted and added to the CCR.

This report provides information on the record linkage process, data validation, and surgical treatment rates for six types of cancer—breast, colorectal, prostate, urinary bladder, thyroid, and lung and bronchus. The project was funded through the Cancer Data Development Initiative (CDDI) of the Canadian Partnership Against Cancer (CPAC n.d.). The linkage was approved by the Statistics Canada Executive Management Board (May 2016) (Statistics Canada n.d.*a*). Use of the linked data is governed by Statistics Canada's Directive on Record Linkage (Statistics Canada n.d.*c*).

2 Data sources

2.1 Canadian Cancer Registry

The Canadian Cancer Registry (CCR) contains information about all cancers diagnosed in Canada, compiled from provincial and territorial cancer registries. It covers all Canadian residents, living and deceased, diagnosed with cancer since 1992, including primary (incident) cancers among patients previously diagnosed with cancer. Every calendar year, the CCR reports confirmed information about each new tumour, including tumour type and date of diagnosis, and demographic data about the patient (Statistics Canada 2008). CCR records from 1992 to 2013 were available for linkage (n = 3,126,295).

2.2 Discharge Abstract Database

The Discharge Abstract Database (DAD) contains demographic, administrative, and coded diagnostic and intervention data for acute care, some psychiatric, chronic rehabilitation, and selected day surgery hospital discharges (CIHI 2010*a*, 2011*a*, 2012*b*, 2012*c*, 2013, 2014*a*, 2015*a*). These are reported annually by all jurisdictions, excluding Quebec, to the Canadian Institute for Health Information (CIHI) on a fiscal year basis (April 1 to March 31). The DAD registers about 3.7 million discharges per year. DAD discharges occurring between April 1, 1994, and March 31, 2015, were available for linkage (n = 77,925,269).

2.3 National Ambulatory Care Reporting System

The National Ambulatory Care Reporting System (NACRS) contains data about visits to health care facilities for ambulatory care, including community-based services, day surgery procedures, emergency department visits, diagnostic imaging, and selected clinic visits (for example, oncology care) (CIHI 2009*b*, 2010*b*, 2011*b*, 2011*c*, 2011*d*, 2012*d*, 2012*e*, 2014*b*, 2015*b*). At each visit, patient demographics, clinical information (diagnoses, surgical interventions), and administrative, financial and service-specific data are recorded. NACRS data are reported to CIHI on a fiscal year basis (April 1 to March 31).

NACRS data are reported most comprehensively by Ontario; less so for other provinces and territories (CIHI 2010*d*). Newfoundland and Labrador, and New Brunswick did not report to the NACRS for all years; Quebec does not report to the NACRS. NACRS records for April 1, 2002, through March 31, 2015, were available for linkage (n = 166,069,085).

2.4 Canadian Vital Statistics Database

The Canadian Vital Statistics (Death) Database (CVSD) compiles demographic and medical (cause of death) information annually from all provincial and territorial vital statistics registries on all deaths in Canada (Statistics Canada n.d.*d*). Deaths occurring from 1970 through 2012 were available for linkage (n = 8,574,561, which includes 731,953 deaths for the 2010-to-2012 period).

3 Record linkage

The linkage was conducted at Statistics Canada using the Social Data Linkage Environment (SDLE), a highly secure linkage environment facilitating the creation of linked population data files for social analysis. The linkage was conducted separately for each database in three steps: (1) data preparation, (2) record linkage, and (3) quality assessment. Given the unique nature of each database, different linking variables, methodologies, and quality assessment measures were employed (Table 1).

3.1 Data preparation

For all four databases—CCR, DAD, NACRS, and CVSD—data preparation included a quality assessment of the linkage variables to determine the completeness and the validity of the data. This procedure identifies data errors or omissions that may impede correct linkage of a record. The choice of linkage variables has a direct impact on the efficiency of the record linkage operation. Information associated with the linkage variables must be accurately recorded, available for the vast majority (if not all) of individuals in the files to be linked, and as discriminating as possible. Each file contained a different set of linkage variables (Table 1). Exclusion criteria varied depending on the linkage strategy.

Table 1
Summary of linkage methodology

Input data file	Number of records	Linkage variables	Exclusion criteria (number of records)	Record linkage method	Quality assessment
CCR	3,126,295	Date of birth, date of death, sex, postal code, city, CSD code, names (given, surnames, CCR alternate names)	None	Probabilistic (G-Link)	Sensitivity Specificity
DAD	77,925,269	Date of birth, postal code, sex, HIN	Records with incomplete date of birth, sex or postal code	Deterministic	False positive
NACRS	166,069,085	Date of birth, postal code, sex, HIN	Records with incomplete date of birth, sex or postal code	Deterministic	False positive
CVSD	8,574,561	Date of birth, date of death, sex, postal code, city, CSD code, names (given, surnames including parents and spouse surname)	Records with names missing (765 records)	Probabilistic (G-Link)	Sensitivity Specificity

Notes: G-Link is a generalized record linkage system developed by Statistics Canada. CSD: census subdivision; HIN: health insurance number.

Sources: Statistics Canada, Canadian Cancer Registry (CCR) and Canadian Vital Statistics Database (CVSD); Canadian Institute for Health Information, Discharge Abstract Database (DAD) and National Ambulatory Care Reporting System (NACRS).

Exclusion criteria were applied to each input data set, where applicable. Because the DAD and the NACRS were linked deterministically using only three variables, missing information for any of the three variables would make an accurate linkage impossible.

In addition, a separate processing step was applied to the CCR to identify unique individuals. Individuals may be represented in the CCR more than once if they were diagnosed with cancer more than once. The CCR data file was unduplicated within provinces and territories, thereby

facilitating linkage at the person level rather than the tumour level. This process identified 3,053,697 unique individual–province combinations. An individual diagnosed with multiple cancers in different provinces or territories would be represented more than once. To handle this situation, the CCR was linked with an N:1 correspondence, that is, more than one individual–province combination could have linked to one DAD record.

3.2 Record linkage methodology

The linkage was conducted at Statistics Canada in the SDLE. At the core of the SDLE is a Derived Record Depository (DRD), a national dynamic relational database containing only basic personal identifiers created by linking selected Statistics Canada source index files in order to produce a list of unique individuals. Each input data file (CCR, NACRS, DAD, CVSD) was separately linked to the DRD using methods appropriate to the availability of linkage variables. The following describes the linkage methodology used for each input file. The methods are summarized in Table 1.

3.3 Canadian Cancer Registry

The CCR was linked to the DRD using G-Link, a generalized record linkage system developed by Statistics Canada based on probabilistic linkage methodology developed by Ivan P. Fellegi and Alan B. Sunter. Probabilistic record linkage uses non-unique identifiers (such as name and birth date) to calculate the likelihood that records refer to the same entity (for example, individual). Probabilistic record linkage is especially valuable when the identifiers are subject to change (females' surnames, for instance), error-prone, or frequently missing. The linkage was conducted using a range of linkage variables, including dates of birth and death, names, and geographic locations (Table 1). If CCR records contained health insurance numbers (HINs), this information was included in the DRD to facilitate linkage to the hospital data. Overall, 95.87% (n = 2,927,463) of unique individual–province identifiers in the CCR were linked to the DRD.

3.4 Discharge Abstract Database and National Ambulatory Care Reporting System

The DAD and NACRS data were linked to the DRD using a two-phase deterministic linkage. In the first phase, a linkage key was created based on sex, date of birth, and postal code for records with complete information (n = 164,649,442). That key was used to deterministically link records to the DRD. Only unique exact matches were retained (only one DRD record linked with a given key). During this phase, HINs in the DAD and the NACRS were extracted and included in the DRD as an additional unique identifier to facilitate future linkages. In the second phase, unlinked records were deterministically linked (exact match) to the DRD using only HINs.

The NACRS was linked first to the DRD. In the first phase, 78.9% (n = 129,985,322) of NACRS records with a valid key were linked to the DRD. A total of 2,895,602 links were broken, reflecting cases where a NACRS record linked to two different people on the DRD, and the conflict could not be resolved with available information. A further 22,953,303 links were created among NACRS records sharing the same HIN, resulting in a total linkage rate of 90.3%.

For the DAD data, 71.2% (n = 55,015,973) of records were linked to the DRD. Another 4,770,333 links were broken, reflecting cases where a DAD record linked to two different people on the DRD, and given the available information, the conflict could not be resolved. A further 11,230,936 links were created among DAD records sharing the same HIN, resulting in a total linkage rate of 85.0%.

3.5 Canadian Vital Statistics Database

The CVSD was linked to the DRD using probabilistic linkage. The linkage was conducted with a range of linkage variables, including dates of birth and death, names, and geographic locations. Overall, 67.1% (n = 5,749,144) of individuals were linked to the DRD. This low rate was expected, given the poor coverage of the DRD before 1980. For the study period (2010 to 2012), the linkage rate was 97.7% (714,825 divided by 731,953).

3.6 Quality assessment

Error estimation was conducted for each linkage to assess the quality of the linkage of each input file to the DRD. For the CCR, sensitivity (true linkage rate) and specificity (true non-linkage rate) were calculated by comparing the results of G-Link to a manual review of a randomly selected sample of links and non-links. The quality of the linkage was deemed high, with sensitivity and specificity rates of 97.74% and 99.36%, respectively. For the CVSD, the sensitivity was 95.4% for the 1970-to-2011 period and 98.4% for 2012. Specificity was 97.8% for the 1970-to-2011 period and 83.5% for 2012.

No manual review was conducted to determine error rates for the DAD and NACRS linkages. However, results of the second phase using HINs provide some measure of the error rate: 0.01% (n = 9,757) of DAD transactions and 0.003% (n = 5,718) of NACRS transactions were linked to different persons in the two phases.

4 Surgical treatment

Further validation was conducted to determine the fitness of the linked data for reporting surgical treatment for six cancer types—female breast, colorectal, prostate, urinary bladder, thyroid, and lung and bronchus—the leading types of new cancers in Canada (Canadian Cancer Society's Advisory Committee on Cancer Statistics 2014). Furthermore, treatment for these cancers typically requires surgical intervention. The following describes the tumour selection process, linkage rates, and treatment rates for these cancers.

4.1 Cohort selection

A cohort of new primary malignant cancer tumours was selected, consisting of people aged 19 or older diagnosed from January 1, 2010, through December 31, 2012. For urinary bladder cancer, *in situ* tumours were also included. *International Classification of Diseases for Oncology, Third Edition* (ICD-O-3) (Fritz et al. 2000) codes were used to define the tumour cohort; these were grouped using Surveillance, Epidemiology, and End Results (SEER) Program grouping definitions (Horner et al. n.d.) (Table 2). Histology for all cancer types excluded: mesothelioma (M-9050 to M-9055), Kaposi sarcoma (M-9140), and hematopoietic and lymphoid neoplasms (M-9590 to M-9992).

Table 2
International Classification of Diseases for Oncology, Third Edition (ICD-O-3) Codes for selecting cancer tumour types

Type	ICD-O-3 Codes
Breast	C50.0 to C50.9
Colorectal	
Colon	C18.0, C18.2 to C18.9; C26.0 (C18.1 appendix was excluded)
Rectum/rectosigmoid junction	C19.9, C20.9
Prostate	C61.9
Lung and bronchus	C34.0 to C34.9
Urinary bladder[1]	C67.0 to C67.9
Thyroid	C73.9

1. In situ tumours were included based on expert opinion suggesting aggressive pathology requiring surgery.
Note: The *SEER Cancer Statistics Review, 1975-2006*, is based on the November 2008 SEER data submission, posted on the website, 2009 (archived).
Source: M.J. Horner et al., n.d., *SEER Cancer Statistics Review, 1975-2006*.

To determine a single primary tumour for each individual, the International Agency for Research on Cancer (IARC) rules (International Agency for Research on Cancer et al. 2004) for multiple primary tumours were applied to the CCR. In general, application of these rules removes subsequent tumours of the same type and histology. This modified CCR file forms the basis of the data released by Statistics Canada to the public (Statistics Canada n.d.*e*) and is accessible to researchers in the Research Data Centres (RDCs). The file is called the IARC Tabulation Master File (TMF) (Statistics Canada 2008).

Individuals may be represented in the IARC TMF more than once if, for example, they were diagnosed with more than one tumour of the same type but of a different histology. To assign surgical treatment at the individual level, it was necessary to ensure that only one tumour of a given type was included for each cancer patient. Hence, a further review of the IARC TMF was conducted to remove tumour records in cases where multiple tumours of the same type were identified for the same patient occurring one year before and/or one year after the date of diagnosis of the primary tumour. This would remove cases of multiple tumours of the same type but different histology, for example.

Reported treatment rates were not age- or sex-adjusted. However in addition to overall surgical treatment rates, rates were produced by sex and by age group (19 to 49, 50 to 69, and 70 or older).

4.2 Treatment codes

A comprehensive list of potential surgical treatments was developed for each cancer type, based on published sources, including the National Comprehensive Cancer Network Clinical Practice Guidelines in Oncology (NCCN Guidelines) (NCCN 2002, 2013*a*, 2013*b*, 2014, 2015*a*, 2015*b*, 2015*c*, 2016) and Facility Oncology Registry Data Standards (FORDS) (Commission on Cancer 2002). The lists pertinent to breast, colorectal and prostate cancers had previously been reviewed by members of the feasibility national advisory committee, technical experts at the provincial cancer agencies, and clinical experts when required (Carrière et al. 2015). After consultations, a final set of surgical treatments was selected. For the three additional cancer types, the initial list of treatments was reviewed, and consultations were held with clinical experts and classification experts from CIHI. Appendix B contains the list of surgical interventions included for each cancer type.

The Canadian Classification of Health Interventions (CCI), versions 2009 and 2012, (CIHI 2009*a*, 2012*a*) were used to define the surgical intervention in the DAD and NACRS. All intervention fields in the DAD (20) and NACRS (10) records were used to identify the surgical interventions

associated with each cancer type. This was done independently for each surgical treatment code because multiple treatments in a single hospital admission are captured as separate treatment events.

4.3 Follow-up period

Surgical treatments occurring within one year after or 31 days before the tumour date of diagnosis recorded on the CCR were considered. The admission date recorded in the DAD and the NACRS was used to determine the eligibility of interventions contained in the record.

4.4 Reporting facility type

The DAD and the NACRS represent different frames of hospital services that are expected to have an impact on reporting treatment rates. The DAD includes all discharges from all acute care facilities for all territories and provinces, except Quebec, and represents about 75% of all acute separations for Canada (CIHI 2012*c*). For the reference period of this analysis (fiscal years 2009/2010 through 2013/2014), health service facilities reported same-day surgery visits to the DAD and/or to the NACRS depending on the year and jurisdiction (CIHI 2009*b*, 2010*b*, 2011*b*, 2011*c*, 2011*d*, 2012*d*, 2012*e*, 2014*b*, 2015*b*). Around 2.4 million day-surgery visits are submitted to CIHI annually—35% are sent to the DAD, and 65%, to the NACRS (CIHI 2012*d*).

The NACRS includes a broader range of services: emergency room visits, day surgery, oncology clinics, Cancer Care Ontario for oncology care, and other types of ambulatory care (for example, renal dialysis clinics) (CIHI 2009*b*, 2010*b*, 2011*b*, 2011*c*, 2011*d*, 2012*d*, 2012*e*, 2014*b*, 2015*b*). The data for provinces that report surgical events to the NACRS offer a greater opportunity to link tumours to surgical treatments (for instance, emergency departments, oncology clinics) than is available for provinces not reporting visits for the same range of services to the NACRS. Consequently, overall treatment rates are expected to be higher in jurisdictions with wider ranges of surgical event coverage. Table 3 displays information on coverage, by reference year, for all jurisdictions. CIHI offers guidelines to prevent double-counting of day-surgery events between the DAD and the NACRS (CIHI 2009*b*).

Table 3
NACRS coverage by year and province or territory (excluding Quebec), 2009/2010 to 2013/2014

Province and Territories	2009/2010	2010/2011	2011/2012	2012/2013	2013/2014
Newfoundland and Labrador	…	…	…	NACRS ED	…
Prince Edward Island	NACRS ED	NACRS ED	NACRS ED	NACRS ED	NACRS ED
Nova Scotia	NACRS ED/DS	NACRS ED/DS	All NACRS	All NACRS	All NACRS
New Brunswick	…	…	…	…	…
Ontario	All NACRS	All NACRS	All NACRS	All NACRS	All NACRS
Manitoba	NACRS ED	NACRS ED	NACRS ED	NACRS ED	NACRS ED
Sasktchewan	…	NACRS ED	NACRS ED	NACRS ED	NACRS ED
Alberta	…	All NACRS	All NACRS	All NACRS	All NACRS
British Columbia	NACRS ED	NACRS ED	NACRS ED	NACRS ED	NACRS ED
Yukon	NACRS ED	NACRS ED	NACRS ED	NACRS ED	NACRS ED
Northwest Territories	…	…	…	…	…
Nunavut	…	…	…	…	…

… not applicable

Notes: Not applicable when day surgeries are reported to the Discharge Abstract Database (DAD) or Alberta Ambulatory Care Reporting System. ED: emergency department; DS: day surgery.

Source: Canadian Institute for Health Information, National Ambulatory Care Reporting System (NACRS).

All in-scope records that contained one or more of the selected surgical interventions that had linked to the six types of cancers in the cohort were considered for analysis of treatment rates; no exclusions based on reporting facility type were applied. Surgeries to treat these cancers can occur outside hospital settings; for example, at specific cancer centres (Winnipeg Regional Health Authority n.d.), in practitioners' offices, and at private clinics. Surgeries performed in those settings were not included in this analysis.

4.5 Surgical treatment rates

Surgical treatment rates for each cancer type are reported by province, and year. Numerators are the number of tumours having at least one occurrence of the selected surgical intervention during the follow-up period. Denominators are the total number of tumours in the CCTLP Tumour Cohort (CCTLP-TC).

5 Results

5.1 Cohort selection

Table 4 presents the selection process for the CCTLP-TC. Overall, 225,330 single primary cancer tumours were selected, representing 97.4% of tumours of the same site reported in the CCR tumour file.

Table 4
Number of primary malignant cancer tumours diagnosed among population aged 19 or older, by cancer type and data source, Canada (excluding Quebec), 2010 to 2012

Primary cancer site	CCR Tabulation Master File (Step A)	IARC Tabulation Master File (Step B)	CCTLP Tumour Cohort (Step C)	CCTLP Tumour Cohort coverage (Step C / Step A)
		number		percentage
Female breast	52,235	51,775	50,740	97.1
Colon and rectum	47,555	45,990	44,970	94.6
Prostate	53,425	53,395	52,905	99.0
Urinary bladder	15,280	15,250	14,990	98.1
Thyroid	12,750	12,750	12,585	98.7
Lung and bronchus	50,110	49,830	49,135	98.1
Total	231,355	228,990	225,330	97.4

Sources: Statistics Canada, Canadian Cancer Registry (CCR) Tabulation Master File, Canadian Cancer Treatment Linkage Project (CCTLP) Tumour Cohort, and International Agency for Research on Cancer (IARC) Tabulation Master File.

The linked tumour cohort median patient age for female breast cancer ranged from 59 to 65 across provinces; for colorectal, from 68 to 73; for prostate, from 65 to 69; for lung and bronchus, from 69 to 72; for urinary bladder, from 66 to 76; and for thyroid, from 47 to 57 (data not shown).

Because cancer outcomes vary for men and women, distributions by sex for four cancer sites were considered. In the linked tumour cohort and across jurisdictions, men accounted for about three-quarters (75% to 76%) of urinary bladder tumours; just over half of colorectal (54% to 55%) and lung and bronchus tumours (51% to 52%); and one-fifth to one-quarter (22% to 24%) of thyroid tumours (data not shown).

5.2 Linkage results for the Canadian Cancer Treatment Linkage Project-Tumour Cohort

Overall, 99% of cancer tumours were linked to the DRD, rendering them eligible to link to a hospital record. Rates were consistent across provinces and territories (where reportable), but were lower for lung and bronchus tumours diagnosed in Nunavut (Table A.1).

Three-year linkage rates for the DAD and NACRS (2009/2010 to 2012/2013) files that were used to identify surgical interventions were greater than 90%. Linkage rates varied across provinces; the lowest levels were reported for the Northwest Territories and Nunavut (Table A.2).

5.3 Treatment rates

Tables 5 to 10 show the percentage of tumours receiving at least one type of surgical intervention during the follow-up period for each type of cancer. The results are presented for all years of data combined. An examination of rates by single years revealed consistent patterns across years (data not shown).

The majority (88%) of female breast cancer tumours received a surgical intervention, with rates ranging from 85% in Manitoba to 92% in Prince Edward Island (Table 5). Rates in the territories were more variable (84% to 93%), owing to smaller numbers of cases. Surgical rates varied by patient age, with the highest among women younger than 70 (Table A.3).

Table 5
Percentage of female breast cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by province or territory, Canada (excluding Quebec), 2010 to 2012

	Linked CCTLP Tumour Cohort	Tumours with one or more surgical interventions	
	number	number	percentage
Canada (excluding Quebec)	**50,740**	**44,780**	**88.2**
Newfoundland and Labrador	1,055	965	91.5
Prince Edward Island	330	305	91.8
Nova Scotia	2,090	1,875	89.7
New Brunswick	1,555	1,410	90.7
Ontario	26,095	22,565	86.5
Manitoba	2,390	2,040	85.3
Saskatchewan	1,940	1,740	89.6
Alberta	6,185	5,575	90.1
British Columbia	8,970	8,195	91.3
Yukon	60	50	84.2
Northwest Territories	60	50	86.7
Nunavut	15	15	93.3

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.
Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Similarly, the majority (83%) of colorectal cancer tumours received a surgical intervention, with rates ranging from 81% to 82% in Ontario and Manitoba to 87% in Newfoundland and Labrador and in British Columbia (Table 6). Because of the smaller numbers of cases, rates for the territories were variable. Colorectal surgical rates were highest at ages 50 to 69 (Table A.4).

Table 6

Percentage of colorectal cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by province or territory, Canada (excluding Quebec), 2010 to 2012

	Linked CCTLP Tumour Cohort	Tumours with one or more surgical interventions	
	number	number	percentage
Canada (excluding Quebec)	**44,970**	**37,315**	**83.0**
Newfoundland and Labrador	1,495	1,295	86.5
Prince Edward Island	300	250	82.5
Nova Scotia	2,330	1,930	82.9
New Brunswick	1,545	1,275	82.5
Ontario	21,510	17,440	81.1
Manitoba	2,385	1,945	81.7
Saskatchewan	2,070	1,745	84.2
Alberta	5,145	4,320	84.0
British Columbia	8,050	6,995	86.9
Yukon	45	40	87.0
Northwest Territories	70	60	84.5
Nunavut	25	20	88.5

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Overall, about a third (31%) of prostate cancer tumours received a surgical intervention. Rates ranged from 17% in Prince Edward Island to 35% in Newfoundland and Labrador and Nova Scotia (Table 7). Annual surgical rates varied considerably (10% to 22%) in Prince Edward Island, a result of the relatively small number of cases in that province (data not shown). In all jurisdictions, the highest rate of surgical intervention was at ages 19 to 49 (Table A.5).

Table 7

Percentage of prostate cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by province or territory, Canada (excluding Quebec), 2010 to 2012

	Linked CCTLP Tumour Cohort	Tumours with one or more surgical interventions	
	number	number	percentage
Canada (excluding Quebec)	**52,905**	**16,480**	**31**
Newfoundland and Labrador	1,350	470	35
Prince Edward Island	420	70	17
Nova Scotia	2,210	775	35
New Brunswick	1,965	490	25
Ontario	26,135	8,085	31
Manitoba	2,045	570	28
Saskatchewan	2,100	515	25
Alberta	6,835	2,325	34
British Columbia	9,765	3,145	32
Yukon	50	30	45
Northwest Territories	x	x	x
Nunavut	x	x	x

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Of the six selected cancer sites, lung and bronchus tumours had the lowest surgical rates—overall, 19% received at least one of surgical intervention. Rates ranged from 14% in Prince Edward Island to 25% in New Brunswick (Table 8). In all jurisdictions, rates were highest at ages 19 to 49 (Table A.6).

Table 8
Percentage of lung and bronchus cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by province or territory, Canada (excluding Quebec), 2010 to 2012

	Linked CCTLP Tumour Cohort	Tumours with one or more surgical interventions	
	number	number	percent
Canada (excluding Quebec)	**49,135**	**9,380**	**19.1**
Newfoundland and Labrador	1,245	195	15.6
Prince Edward Island	360	50	13.6
Nova Scotia	2,680	535	20.0
New Brunswick	1,950	490	25.1
Ontario	24,205	4,765	19.7
Manitoba	2,460	560	22.9
Saskatchewan	2,200	385	17.5
Alberta	5,425	955	17.6
British Columbia	8,475	1,420	16.8
Yukon	50	10	19.6
Northwest Territories	x	x	x
Nunavut	x	x	x

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

A large majority (91%) of bladder tumours received surgical treatment; rates were high in all jurisdictions, ranging from 88% in Manitoba and Ontario to 94% in Newfoundland and Labrador (Table 9). The highest rates were at ages 50 to 69 (Table A.7).

Table 9
Percentage of urinary bladder (including in situ) cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by province or territory, Canada (excluding Quebec), 2010 to 2012

	Linked CCTLP Tumour Cohort	Tumours with one or more surgical interventions	
	number	number	percent
Canada (excluding Quebec)	**14,990**	**13,590**	**91**
Newfoundland and Labrador	380	355	94
Prince Edward Island	105	100	92
Nova Scotia	845	785	93
New Brunswick	675	620	92
Ontario	6,055	5,360	88
Manitoba	765	675	88
Saskatchewan	740	680	92
Alberta	2,090	1,910	92
British Columbia	3,315	3,075	93
Yukon	15	15	88
Northwest Territories	x	x	x
Nunavut	x	x	x

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Most thyroid tumours received at least one surgical treatment. The overall rate was 93%, ranging from 91% in Prince Edward Island, Manitoba and British Columbia to 98% in Newfoundland and Labrador (Table 10). Thyroid surgical patients tended to be younger than those who had surgery on other cancer sites; the lowest rates were among patients aged 70 or older (Table A.8).

Table 10
Percentage of thyroid cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by province or territory, Canada (excluding Quebec), 2010 to 2012

	Linked CCTLP Tumour Cohort	Tumours with one or more surgical interventions	
	number	number	percent
Canada (excluding Quebec)	**12,585**	**11,700**	**93**
Newfoundland and Labrador	315	310	98
Prince Edward Island	35	30	91
Nova Scotia	360	345	96
New Brunswick	410	400	97
Ontario	8,320	7,690	92
Manitoba	380	350	91
Saskatchewan	280	265	95
Alberta	1,340	1,270	95
British Columbia	1,125	1,030	91
Yukon	x	x	x
Northwest Territories	5	5	86
Nunavut	x	x	x

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

6 Discussion

This study demonstrates how record linkage can be used to add surgical treatment information to a national cancer registry. By means of the SDLE platform at Statistics Canada, most records in the CCR, the DAD and the NACRS were linked. The surgical treatment rates for the six selected cancers derived from the linked data reflected expected values. Because they are based on the majority of tumours of the selected types diagnosed between 2010 and 2012, the results are deemed unbiased and representative of the surgical treatment experience of cancer patients in Canada.

The linkage rates achieved for each input file were 90% or better; the rate was 99% for the selected cancer tumours diagnosed from 2010 to 2012 among adult patients. For the DAD, rates were highest for the most recent years of data and for records representing patients aged 19 or older.

An advantage of conducting the linkage at the national level is the ability to capture surgical treatments occurring outside patients' province or territory of residence. Generally, national-level linkage rates equal or exceed rates from previous linkage projects (Carrière et al. 2015; Rotermann et al. 2014, 2015). Nonetheless, some regional variation in linkage rates was apparent for the DAD. Continued efforts are required to improve DAD linkage rates, specifically, for selected regions, including the Northwest Territories and Nunavut, to ensure comparability.

DAD linkage rates were higher when HINs were available. However, not all cancer registries currently report HINs to the CCR. Continued use of HINs as a linkage variable would increase the pan-Canadian linkage rate, but differentially affect rates for reporting and non-reporting provinces and territories. Requesting HINs is part of the CCR annual cancer data call; comprehensive submission from all provincial and territorial cancer registries would help to resolve this issue. In

addition, an assessment of the quality of HIN reporting to the CCR should be undertaken before it is assigned a primary role in linkage with the DAD or other datasets.

Surgical treatment rates derived from the linked CCR–DAD–NACRs data are generally at expected levels and comparable to published information on surgical rates. As anticipated, surgical rates varied by cancer site and were higher for breast, colorectal, urinary bladder, and thyroid cancers, compared with lung cancer, for which survival outcomes are poor, and prostate cancer, for which " active surveillance" may be the preferred approach (Dragomir, Cury and Aprikian 2014).

The results of this study indicated that breast-conserving surgery and mastectomy were the most prevalent types of surgical treatment for breast cancer. Other published sources have identified these surgeries as integral to breast cancer treatment (Urbach, Simunovic and Schultz 2008; Quan et al. 2008; CIHI and CPAC 2012; Turner et al. 2007). Combined breast-conserving surgery and/or mastectomy rates resemble those previously reported for Ontario and Manitoba (Quan et al. 2008; CIHI and CPAC 2012; Turner et al. 2007). Furthermore, disaggregated breast surgical rates used for validation (data not shown) showed similarities to published results for cancer system performance reports (CPAC 2012, 2016). Compared with rates calculated for four provinces during the 2005-to-2008 period (Carrière et al. 2015), the breast surgery rates in this study are slightly lower or higher, possibly because of different linkage approaches. This demonstrates that use of the SDLE platform yielded higher rates for breast surgeries for two provinces than had been obtained via direct linkage using only HINs reported to the CCR in the earlier feasibility study.

The present analyses revealed differences in breast surgery by patient age (data not shown). Therefore, some variation in treatment rates across jurisdictions or in comparison with other reports is due, in part, to differences in the age distribution of this cohort. Further analysis is required to assess treatment rates for all six cancers by patient characteristics and cancer stage.

Surgery rates for colorectal cancer in Ontario were similar to published findings (Carrière et al. 2015; Nenshi et al. 2008). Surgical treatment rates were highest at ages 19 to 49, consistent with results noted in the earlier feasibility report (Carrière et al. 2015).

A decade ago, an analysis of U.S. data found that 93.4% of nearly 54,000 thyroid cancers (histologies taken together) received surgical treatment (thyroidectomy and/or lymph node sampling and/or dissection) (Hundahl et al. 1998). According to the present study, 93% of thyroid tumours received at least one surgical treatment, primarily thyroidectomy.

Patients with urinary bladder cancer frequently experience recurrence (Kassouf et al. 2010), and with the prevalence of this cancer being 10 times its incidence (Kassouf et al. 2010), the likelihood of at least one surgical treatment was expected to be high. In fact, rates consistently exceeded 91%. Treatment rates were not calculated by tumour stage; however, this likely would impact rates for surgery. A retrospective review using Alberta Cancer Registry data from 2007 to 2011 reported that overall, 27.8% of high-grade T1 bladder cancer experienced early repeat resection, and that by 2011, the rate had increased to 37.8% (Gotto, Shea-Budgell, and Ruether 2016). For future analyses, the record linkage approach in this study would enable measurement of changes in surgical patterns across time.

The utility of linked data about surgery for cancer depends in part on the accuracy and comprehensiveness of hospital data. Evidence suggests that cancer registry information about surgical treatment is more complete than information in the DAD (Turner et al. 2007). Consequently, this analysis may underestimate treatment rates. As well, DAD and NACRS coding standards may limit the degree to which the data can be used to report specific surgical interventions. For example, previous research found lower-than-expected rates of lymph node removal for breast and prostate cancer (Carrière et al. 2015). This was attributed, in part, to the

fact that multiple axillary lymph node procedures are not always recorded separately in the DAD when radical mastectomy and prostatectomy are performed. Therefore, obtaining comprehensive or absolute counts of lymph node interventions is not feasible for all years of DAD and NACRS data. Mandatory reporting guidelines may have addressed this issue in more recent years of DAD and NACRS data. Further analyses of these newly linked data are required to determine the accuracy of reporting more specific surgical interventions.

Finally, results of this and previous studies have demonstrated the feasibility of using hospital data (such as data from the DAD and NACRS) linked to cancer registry data to derive surgical treatment rates. This approach is appropriate when interventions occur primarily in hospital or clinic settings that report to one of the two national hospital data sources. It may not be appropriate for some types of cancers (such as skin cancer) for which surgical interventions may occur in physicians' offices. Linkage to physician claims data would be required to capture this information.

7 Limitations

Although the linkage rates were considered to be robust for both the DAD and NACRS, the 8% of non-linking cases potentially represent missed surgical treatments. Furthermore, the feasibility of using record linkage to capture surgical interventions to report on treatment for childhood cancers warrants further investigation, as overall linkage rates for DAD records related to children were generally lower (data not shown).

The current study was based on the majority of tumours (97.4%) of the selected cancer types, excluding cases where: (1) more than one primary tumour in the same organ was reported to the CCR; (2) the diagnosis dates were within 365 days of each other; and (3) the tumour record did not link in the SDLE. The overall impact was a loss of 2.6% of tumours reported to the CCR. Colorectal cases were most affected, with a loss of 5.4%, followed by female breast with a loss of 2.9%. The impact of multiple tumours may be more pronounced for other cancer sites. Given the overall high linkage rate for the CCR, most exclusions were based on criteria 1 and 2. The challenge presented by multiple tumours is proper attribution of a surgical intervention. The results of this study cannot be generalized to cases with multiple tumours. Future work should focus on determining the feasibility of using record linkage to correctly assign surgical information to the appropriate tumour in such cases.

Except for urinary bladder cancer, this study did not include *in situ* tumours. Future studies should attempt to include them, and thereby, determine the feasibility of using linked data to report on treatment rates for these tumours.

Surgical treatments that may have occurred outside of hospital settings, for example, prostate surgery in physician's office or surgery at the Winnipeg Breast Health Centre (Winnipeg Regional Health Authority n.d.) were not captured in the data used in this study. Therefore, surgical treatment rates are slightly underestimated.

8 Conclusions

Results of this study demonstrate the feasibility of using record linkage to bring together information in cancer registries with surgical intervention information in hospital data. The use of Statistics Canada's linkage environment, SDLE, is a viable, cost-effective method of adding surgical treatment data to the CCR, and thereby, enhancing the capacity to report on a key treatment modality at the national level. Future work should focus on continued improvement of linkage rates, specifically, for hospital data; the feasibility of extending this approach to cases representing multiple tumours, younger patients, and other types of cancers; and the quality of surgical data.

Appendix A – Additional tables on linkage results

Table A.1-1
Number and percentage of tumours from the CCTLP Tumour Cohort that are linked to the DRD, by type of cancer and province or territory, Canada (excluding Quebec), 2010 to 2012 — Female breast, colorectal and prostate cancers

	CCTLP Tumour Cohort	Tumour records linked to DRD	
	number	number	percent
Female breast			
Canada	**51,200**	**50,740**	**99.1**
Newfoundland and Labrador	1,070	1,055	98.5
Prince Edward Island	330	330	100.0
Nova Scotia	2,100	2,090	99.5
New Brunswick	1,565	1,555	99.4
Ontario	26,385	26,095	98.9
Manitoba	2,405	2,390	99.5
Saskatchewan	1,955	1,940	99.2
Alberta	6,220	6,185	99.4
British Columbia	9,035	8,970	99.3
Yukon	60	60	100.0
Northwest Territories	60	60	100.0
Nunavut	15	15	100.0
Colorectal			
Canada	**45,450**	**44,970**	**99.0**
Newfoundland and Labrador	1,515	1,495	98.7
Prince Edward Island	305	300	99.0
Nova Scotia	2,340	2,330	99.4
New Brunswick	1,555	1,545	99.4
Ontario	21,805	21,510	98.6
Manitoba	2,400	2,385	99.3
Saskatchewan	2,090	2,070	99.0
Alberta	5,175	5,145	99.4
British Columbia	8,110	8,050	99.2
Yukon	50	45	97.9
Northwest Territories	70	70	98.6
Nunavut	30	25	92.9
Prostate			
Canada	**53,355**	**52,905**	**99.2**
Newfoundland and Labrador	1,360	1,350	99.2
Prince Edward Island	420	420	99.8
Nova Scotia	2,220	2,210	99.4
New Brunswick	1,975	1,965	99.3
Ontario	26,440	26,135	98.9
Manitoba	2,055	2,045	99.5
Saskatchewan	2,110	2,100	99.4
Alberta	6,865	6,830	99.5
British Columbia	9,820	9,765	99.4
Yukon	50	50	100.0
Northwest Territories	25	25	100.0
Nunavut	10	10	90.0

Notes: Numbers have been rounded to nearest 5; percentages based on unrounded counts. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; DRD: Derived Record Depository; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.1-2
Number and percentage of tumours from the CCTLP Tumour Cohort that are linked to the DRD, by type of cancer and province or territory, Canada (excluding Quebec), 2010 to 2012 — Urinary bladder, thyroid, and lung and bronchus cancers

	CCTLP Tumour Cohort	Tumour records linked to DRD	
	number	number	percent
Urinary bladder (including in situ)			
Canada	**15,125**	**14,990**	**99.1**
Newfoundland and Labrador	380	380	99.2
Prince Edward Island	105	105	99.1
Nova Scotia	855	840	98.8
New Brunswick	680	675	99.6
Ontario	6,120	6,055	99.0
Manitoba	770	765	99.4
Saskatchewan	745	740	99.3
Alberta	2,095	2,090	99.6
British Columbia	3,345	3,315	99.1
Yukon	20	15	89.5
Northwest Territories	x	x	x
Nunavut	x	x	x
Thyroid			
Canada	**12,710**	**12,585**	**99.0**
Newfoundland and Labrador	315	315	100.0
Prince Edward Island	30	30	100.0
Nova Scotia	360	360	100.0
New Brunswick	415	410	99.5
Ontario	8,425	8,320	98.8
Manitoba	385	380	99.5
Saskatchewan	280	280	98.9
Alberta	1,350	1,340	99.2
British Columbia	1,135	1,125	99.4
Yukon	x	x	x
Northwest Territories	5	5	100.0
Nunavut	x	x	x
Lung and bronchus			
Canada	**49,570**	**49,135**	**99.1**
Newfoundland and Labrador	1,260	1,245	99.0
Prince Edward Island	360	360	99.7
Nova Scotia	2,700	2,680	99.3
New Brunswick	1,960	1,950	99.3
Ontario	24,460	24,205	99.0
Manitoba	2,470	2,456	99.5
Saskatchewan	2,215	2,200	99.3
Alberta	5,465	5,425	99.3
British Columbia	8,530	8,475	99.3
Yukon	50	50	98.1
Northwest Territories	45	45	100.0
Nunavut	50	45	90.2

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers have been rounded to nearest 5; percentages based on unrounded counts. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; DRD: Derived Record Depository; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.2-1
Number and percentage of DAD and NACRS records linked to the DRD, by province or territory, Canada (excluding Quebec), 2009/2010 through 2013/2014 — Part 1

	DAD records	DAD records linked to DRD		NACRS records	NACRS records linked to DRD	
	number	number	percent	number	number	percent
Fiscal year 2009/2010						
Canada (excluding Quebec)	**2,745,705**	**2,520,970**	**91.8**	**8,028,690**	**7,485,470**	**93.2**
Newfoundland and Labrador	117,230	102,665	87.6	…	…	…
Prince Edward Island	24,695	20,480	82.9	22,045	20,155	91.4
Nova Scotia	183,875	171,920	93.5	59,900	55,130	92.0
New Brunswick	127,990	108,795	85.0	…	…	…
Ontario	869,990	816,090	93.8	7,819,305	7,294,805	93.3
Manitoba	206,765	178,290	86.2	88,140	79,975	90.7
Saskatchewan	209,545	193,925	92.5	…	…	…
Alberta	291,535	268,105	92.0	…	…	…
British Columbia	700,930	652,390	93.1	17,410	16,165	92.8
Yukon	4,350	3,830	88.0	21,885	19,240	87.9
Northwest Territories	7,020	3,670	52.3	…	…	…
Nunavut	1,795	825	46.0	…	…	…
Fiscal year 2010/2011						
Canada (excluding Quebec)	**2,767,960**	**2,549,220**	**92.1**	**14,021,400**	**13,053,095**	**93.1**
Newfoundland and Labrador	118,075	103,660	87.8	…	…	…
Prince Edward Island	24,530	20,315	82.8	20,785	19,050	91.6
Nova Scotia	182,895	170,980	93.5	54,740	50,280	91.9
New Brunswick	126,615	107,765	85.1	…	…	…
Ontario	874,065	820,445	93.9	7,756,950	7,236,430	93.3
Manitoba	207,840	181,775	87.5	250,740	226,660	90.4
Saskatchewan	209,565	194,320	92.7	6,640	5,685	85.6
Alberta	293,040	272,485	93.0	5,908,865	5,495,200	93.0
British Columbia	718,060	669,025	93.2	…	…	…
Yukon	4,430	3,900	88.1	22,680	19,785	87.3
Northwest Territories	7,120	3,820	53.6	…	…	…
Nunavut	1,730	735	42.5	…	…	…
Fiscal year 2011/2012						
Canada (excluding Quebec)	**2,710,770**	**2,499,585**	**92.2**	**14,904,220**	**13,848,210**	**92.9**
Newfoundland and Labrador	118,100	104,070	88.1	…	…	…
Prince Edward Island	24,605	20,610	83.8	20,575	18,990	92.3
Nova Scotia	78,265	72,930	93.2	295,620	272,895	92.3
New Brunswick	126,915	108,910	85.8	…	…	…
Ontario	888,790	834,585	93.9	7,948,715	7,417,460	93.3
Manitoba	208,230	183,295	88.0	249,370	226,040	90.6
Saskatchewan	210,685	195,430	92.8	90,650	82,400	90.9
Alberta	302,975	281,985	93.1	6,006,525	5,580,830	92.9
British Columbia	739,200	689,360	93.3	265,480	225,700	85.0
Yukon	4,525	3,955	87.4	27,290	23,900	87.6
Northwest Territories	6,795	3,720	54.8	…	…	…
Nunavut	1,690	735	43.6	…	…	…

… not applicable

Notes: Numbers have been rounded to base 5. DAD: Discharge Abstract Database; DRD: Derived Record Depository; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.2-2
Number and percentage of DAD and NACRS records linking to the DRD, by province or territory, Canada (excluding Quebec), 2009/2010 through 2013/2014 — Part 2

	DAD records	DAD records linked to DRD		NACRS records	NACRS records linked to DRD	
	number	number	percent	number	number	percent
Fiscal year 2012/2013						
Canada (excluding Quebec)	**2,718,850**	**2,509,485**	**92.3**	**15,641,385**	**14,491,755**	**92.7**
Newfoundland and Labrador	119,110	104,750	87.9	…	…	…
Prince Edward Island	23,825	19,835	83.3	20,465	18,755	91.6
Nova Scotia	76,885	71,780	93.4	293,400	271,140	92.4
New Brunswick	124,895	109,375	87.6	…	…	…
Ontario	899,170	843,755	93.8	8,003,225	7,462,265	93.2
Manitoba	202,950	178,875	88.1	239,980	217,685	90.7
Saskatchewan	210,500	195,200	92.7	164,285	148,905	90.6
Alberta	306,990	285,370	93.0	6,096,535	5,643,620	92.6
British Columbia	741,790	692,100	93.3	796,030	705,355	88.6
Yukon	4,660	4,170	89.5	27,460	24,025	87.5
Northwest Territories	6,490	3,575	55.1	…	…	…
Nunavut	1,590	700	44.1	…	…	…
Fiscal year 2013/2014						
Canada (excluding Quebec)	**2,756,330**	**2,528,845**	**91.7**	**16,163,640**	**14,848,360**	**91.9**
Newfoundland and Labrador	125,340	110,005	87.8	…	…	…
Prince Edward Island	25,010	20,955	83.8	19,885	18,305	92.1
Nova Scotia	76,395	70,960	92.9	304,890	280,070	91.9
New Brunswick	123,695	107,920	87.2	…	…	…
Ontario	903,945	844,505	93.4	8,038,000	7,458,245	92.8
Manitoba	200,825	176,250	87.8	226,720	201,490	88.9
Saskatchewan	213,485	196,955	92.3	159,495	142,815	89.5
Alberta	312,115	287,020	92.0	6,400,260	5,857,825	91.5
British Columbia	763,005	706,160	92.5	988,030	867,030	87.8
Yukon	4,240	3,720	87.8	26,360	22,580	85.7
Northwest Territories	6,660	3,675	55.1	…	…	…
Nunavut	1,615	715	44.4	…	…	…

… not applicable

Notes: Numbers have been rounded to base 5. DAD: Discharge Abstract Database; DRD: Derived Record Depository; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.3

Number and percentage of female breast cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by age group and province or territory, Canada (excluding Quebec), 2010 to 2012

	19 to 49 years			50 to 69 years			70 years and older		
	Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention	
	number	number	percent	number	number	percent	number	number	percent
Canada (excluding Quebec)	**10,300**	**9,355**	**90.8**	**25,255**	**23,020**	**91.1**	**14,150**	**11,930**	**84.3**
Newfoundland and Labrador	190	190	98.4	560	530	94.3	290	245	84.1
Prince Edward Island	40	40	97.7	180	170	94.9	100	85	87.6
Nova Scotia	405	385	95.0	1,030	970	94.4	600	500	82.6
New Brunswick	250	240	97.6	790	755	95.3	490	410	83.1
Ontario	5,530	4,890	88.3	12,930	11,550	89.3	7,165	5,915	82.5
Manitoba	430	390	90.9	1,180	1,050	89.0	710	580	81.4
Saskatchewan	295	270	91.5	915	860	94.0	665	580	86.8
Alberta	1,420	1,315	92.6	3,075	2,825	91.8	1,585	1,380	86.9
British Columbia	1,715	1,620	94.2	4,520	4,240	93.9	2,520	2,230	88.6
Yukon	10	10	83.3	30	30	90.6	15	10	69.2
Northwest Territories	x	x	81.3	40	35	91.9	x	x	71.4
Nunavut	x	x	80.0	10	10	100.0	x	x	100.0

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. A total of 1,035 female breast tumours were missing age information (2% in a given year), 480 of which received one or more surgical treatments. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.4

Number and percentage of colorectal cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by age group and province or territory, Canada (excluding Quebec), 2010 to 2012

	19 to 49 years			50 to 69 years			70 years and older		
	Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention	
	number	number	percent	number	number	percent	number	number	percent
Canada (excluding Quebec)	**3,235**	**2,710**	**83.7**	**18,750**	**16,305**	**87.0**	**21,270**	**17,415**	**81.9**
Newfoundland and Labrador	110	100	88.9	675	625	92.6	685	565	82.3
Prince Edward Island	15	10	75.0	110	100	91.1	160	130	80.7
Nova Scotia	120	100	84.9	990	875	88.6	1,110	905	81.4
New Brunswick	10	90	87.1	670	575	86.1	720	590	82.0
Ontario	1,630	1,320	81.0	8,900	7,470	83.9	10,240	8,250	80.6
Manitoba	165	135	81.8	960	840	87.2	1,140	910	79.9
Saskatchewan	130	110	86.2	860	770	89.3	970	815	83.9
Alberta	430	370	86.0	2,285	2,040	89.4	2,275	1,835	80.7
British Columbia	520	460	88.1	3,210	2,935	91.3	3,940	3,385	86.0
Yukon	x	x	100.0	30	25	85.7	x	x	85.7
Northwest Territories	10	10	87.5	50	40	84.8	20	15	82.4
Nunavut	x	x	100.0	15	15	87.5	x	x	85.7

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. A total of 1,720 colorectal tumours were missing age information (3.8% in a given year), 890 of which received one or more surgical treatments. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.5

Number and percentage of prostate cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by age group and province or territory, Canada (excluding Quebec), 2010 to 2012

	19 to 49 years			50 to 69 years			70 years and older		
	Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention	
	number	number	percent	number	number	percent	number	number	percent
Canada (excluding Quebec)	**1,210**	**695**	**57.4**	**30,550**	**13,520**	**44.2**	**20,385**	**2,255**	**11.1**
Newfoundland and Labrador	25	20	83.3	865	415	48.2	455	35	7.7
Prince Edward Island	x	x	x	260	60	23.1	x	x	x
Nova Scotia	55	35	65.5	1,335	625	46.7	785	115	14.8
New Brunswick	45	25	52.3	1,260	415	33.1	635	45	7.2
Ontario	625	350	55.6	15,145	6,755	44.6	10,040	980	9.7
Manitoba	35	15	41.2	1,110	480	43.3	840	75	8.7
Saskatchewan	40	20	51.2	1,150	410	35.5	860	85	9.8
Alberta	245	145	59.1	4,175	1,850	44.3	2,340	330	14.2
British Columbia	130	80	63.3	5,190	2,480	47.8	4,270	580	13.5
Yukon	x	x	x	35	20	55.9	x	x	x
Northwest Territories	x	x	x	20	5	31.6	x	x	x
Nunavut	0	0	0.0	x	x	x	x	x	x

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. A total of 760 prostate tumours were missing age information (1.4% in a given year), 15 of which received one or more surgical treatments. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.6

Number and percentage of lung and bronchus cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis, by age group and province or territory, Canada (excluding Quebec), 2010 to 2012

	19 to 49 years			50 to 69 years			70 years and older		
	Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention	
	number	number	percent	number	number	percent	number	number	percent
Canada (excluding Quebec)	**1,615**	**440**	**27.2**	**21,110**	**4,955**	**23.5**	**25,300**	**3,980**	**15.7**
Newfoundland and Labrador	30	5	22.6	600	130	19.8	600	70	11.2
Prince Edward Island	10	x	x	165	30	19.5	x	x	x
Nova Scotia	65	20	29.2	1,155	310	26.9	1,400	205	14.7
New Brunswick	55	20	37.0	885	280	31.7	960	190	19.6
Ontario	865	235	27.1	10,480	2,455	23.4	12,375	2,075	16.7
Manitoba	75	25	32.9	1,040	290	27.6	1,245	250	20.0
Saskatchewan	60	15	23.0	875	210	23.8	1,205	160	13.5
Alberta	190	50	27.4	2,310	505	21.9	2,810	395	14.0
British Columbia	260	65	25.4	3,515	740	21.1	4,460	615	13.8
Yukon	x	x	x	30	5	20.7	x	x	x
Northwest Territories	x	x	x	25	x	x	20	x	x
Nunavut	x	0	0.0	25	x	x	x	x	x

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. A total of 1,110 lung and bronchus tumours were missing age information (2.2% in a given year), 5 of which received one or more surgical treatments. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.7

Number and percentage of urinary bladder cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis by age group and province or territory, Canada (excluding Quebec), 2010 to 2012

	19 to 49 years			50 to 69 years			70 years and older		
	Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention	
	number	number	percent	number	number	percent	number	number	percent
Canada (excluding Quebec)	**580**	**525**	**90.7**	**5,485**	**5,125**	**93.5**	**8,255**	**7,455**	**90.3**
Newfoundland and Labrador	10	10	90.9	165	155	95.7	195	180	93.8
Prince Edward Island	x	x	x	40	40	92.9	x	x	x
Nova Scotia	25	20	95.7	345	330	95.7	440	405	91.9
New Brunswick	30	30	93.8	265	250	94.0	345	320	92.2
Ontario	215	185	85.6	2,095	1,905	91.0	3,465	3,065	88.5
Manitoba	20	15	89.5	295	270	92.5	415	360	87.4
Saskatchewan	40	35	94.7	250	240	94.5	400	370	92.3
Alberta	115	105	91.2	845	795	94.1	1,070	970	90.7
British Columbia	120	115	95.8	1,170	1,125	96.3	1,860	1,720	92.5
Yukon	x	x	x	10	10	88.9	x	x	x
Northwest Territories	0	0	0.0	x	x	x	x	x	x
Nunavut	0	0	0.0	x	x	x	x	x	x

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. A total of 650 urinary bladder tumours were missing age information (4.5% in a given year), 480 of which received one or more surgical treatments. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Table A.8

Number and percentage of thyroid cancer tumours diagnosed among patients aged 19 or older with at least one surgical treatment within one year of diagnosis by age group and province or territory, Canada (excluding Quebec), 2010 to 2012

	19 to 49 years			50 to 69 years			70 years and older		
	Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention		Linked CCTLP Tumour Cohort	Tumours with one or more surgical intervention	
	number	number	percent	number	number	percent	number	number	percent
Canada (excluding Quebec)	**6,070**	**5,745**	**94.7**	**5,120**	**4,775**	**93.3**	**1,360**	**1,170**	**86.1**
Newfoundland and Labrador	125	125	100.0	145	145	98.6	45	40	93.3
Prince Edward Island	10	10	100.0	15	10	80.0	5	5	100.0
Nova Scotia	140	135	96.4	160	160	98.8	55	50	92.9
New Brunswick	140	145	100.0	215	215	98.6	50	45	81.1
Ontario	4,095	3,855	94.1	3,380	3,115	92.2	830	715	86.5
Manitoba	185	170	90.9	145	140	94.6	45	40	84.4
Saskatchewan	135	135	98.5	105	100	96.2	35	30	80.0
Alberta	720	695	96.7	495	470	94.5	125	105	85.5
British Columbia	505	470	93.5	450	420	92.9	165	140	83.1
Yukon	x	x	0.0	x	x	100.0	x	x	100.0
Northwest Territories	x	x	0.0	x	x	100.0	0	0	0.0
Nunavut	x	x	0.0	x	x	100.0	x	x	0.0

x suppressed to meet the confidentiality requirements of the *Statistics Act*

Notes: Numbers rounded to nearest 5; percentages based on unrounded counts. A total of 35 thyroid tumours were missing age information (less than 1% in a given year), 10 of which received one or more surgical treatments. CCTLP: Canadian Cancer Treatment Linkage Project; DAD: Discharge Abstract Database; IARC: International Agency for Research on Cancer; NACRS: National Ambulatory Care Reporting System; TMF: Tabulation Master File.

Sources: Statistics Canada, February 2015 IARC TMF and IARC–DAD–NACRS linked database.

Appendix B – Surgical treatments for cancer primary sites

Table B.1-1
Primary site surgical treatments and CIHI intervention codes — Breast, colorectal and prostate cancers

Cancer type and physical/physiological therapeutic intervention	Intervention code
Breast	
Excision partial, nipple	1.YK.87.^^
Excision total, nipple	1.YK.87.^^
Excision partial, breast	1.YM.87.^^
Excision partial with reconstruction, breast	1.YM.88.^^
Excision total, breast	1.YM.89.^^
Excision total with reconstruction, breast	1.YM.90.^^
Excision radical, breast	1.YM.91.^^
Excision radical with reconstruction, breast	1.YM.92.^^
Excision partial, lymph node(s), axillary	1.MD.87.^^
Excision total, lymph node(s), axillary	1.MD.89.^^
Colorectal	
Excision partial, large intestine	1.NM.87.^^
Excision total, large intestine	1.NM.89.^^
Excision radical, large intestine	1.NM.91.^^
Excision partial, rectum	1.NQ.87.^^
Excision total, rectum	1.NQ.89.^^
Excision partial, lymph node(s), pelvic	1.MH.87.^^
Excision total, lymph node(s), pelvic	1.MH.89.^^
Excision partial, lymph node(s), intra abdominal	1.MG.87.^^
Excision total, lymph node(s), intra abdominal	1.MG.89.^^
Bypass, large intestine	1.NM.76.^^
Bypass with exteriorization, large intestine	1.NM.77.^^
Reattachment, large intestine	1.NM.82.^^
Construction or reconstruction, rectum	1.NQ.84.^^
Prostate	
Excision radical, prostate	1.QT.91.^^
Excision radical, bladder NEC	1.PM.91.^^
Excision radical with reconstruction, bladder NEC	1.PM.92.^^
Excision total, testis	1.QM.89.^^
Excision radical, testis	1.QM.91.^^
Destruction, prostate	1.QT.59.^^
Excision partial, lymph node(s), pelvic	1.MH.87.^^
Excision total, lymph node(s), pelvic	1.MH.89.^^

Notes: Primary site surgical treatments include one or more of any of the listed surgical treatments, at least once. Each intervention code denotes the information found in its corresponding intervention name. NEC: not elsewhere classified.

Source: CIHI (Canadian Institute for Health Information), 2009, *Canadian Classification of Health Interventions (CCI): Volume three–Tabular List.*

Table B.1-2
Primary site surgical treatments and CIHI intervention codes — Urinary bladder, lung and thyroid cancers

Cancer type and physical/physiological therapeutic intervention	Intervention code
Urinary bladder	
Excision partial, bladder neck	1.PL.87.^^
Excision partial, bladder	1.PM.87.^^
Excision total, bladder	1.PM.89.^^
Excision total with reconstruction, bladder	1.PM.90.^^
Excision radical, bladder	1.PM.91.^^
Excision radical with reconstruction, bladder	1.PM.92.^^
Destruction, bladder	1.PM.59.^^
Excision partial, lymph node(s), pelvic	1.MH.87.^^
Excision total, lymph node(s), pelvic	1.MH.89.^^
Lung	
Excision partial, lobe of lung	1.GR.87.^^
Excision total, lobe of lung	1.GR.89.^^
Excision radical, lobe of lung	1.GR.91.^^
Excision partial, lung NEC	1.GT.87.^^
Excision total, lung NEC	1.GT.89.^^
Excision radical, lung NEC	1.GT.91.^^
Excision radical with reconstruction, carina	1.GN.92.^^
Excision partial, lymph node(s), mediastinal	1.ME.87.^^
Excision total, lymph node(s), mediastinal	1.ME.89.^^
Excision partial, lymph node(s), intrathoracic NEC	1.MF.87.^^
Excision partial, lymph node(s), cervical	1.MC.87.^^
Excision total, lymph node(s), cervical	1.MC.89.^^
Excision radical, lymph node(s), cervical	1.MC.91.^^
Thyroid	
Excision partial, thyroid gland	1.FU.87^^
Excision total, thyroid gland	1.FU.89^^
Excision total, parathyroid gland	1.FV.89.^^
Excision radical, larynx NEC	1.GE.91.^^
Excision partial, mediastinum	1.GW.87.^^
Excision partial, lymph node(s), mediastinal	1.ME.87.^^
Excision total, lymph node(s), mediastinal	1.ME.89.^^
Excision partial, lymph node(s), deep cervical	1.MB.87.^^
Excision partial, lymph node(s), cervical	1.MC.87.^^
Excision total, lymph node(s), cervical	1.MC.89.^^
Excision radical, lymph node(s), cervical	1.MC.91.^^
Excision partial, intrathoracic lymph nodes	1.MF.87.^^

Notes: Primary site surgical treatments include one or more of any of the listed surgical treatments, at least once. Each intervention code denotes the information found in its corresponding intervention name. NEC: not elsewhere classified.

Source: CIHI (Canadian Institute for Health Information), 2009, *Canadian Classification of Health Interventions (CCI): Volume three–Tabular List.*

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