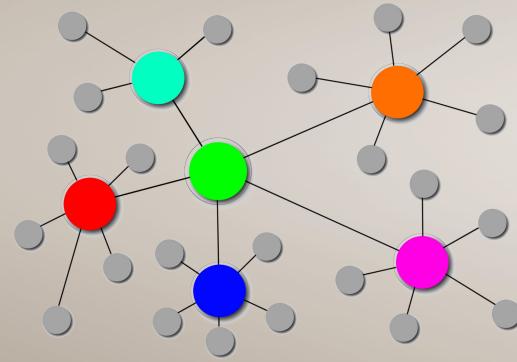
CANCER DATA LINKAGE IN MANITOBA: **EXPANDING THE INFRASTRUCTURE** FOR RESEARCH



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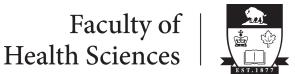
This report was prepared at the request of Manitoba Health, Healthy Living and Seniors (MHHLS) as part of the contract between the University of Manitoba and MHHLS. It was supported through funding provided by the Department of Health of the Province of Manitoba to the University of Manitoba (HIPC 2014/2015-02). The results and conclusions are those of the authors and no official endorsement by MHHLS was intended or should be inferred. Data used in this study are from the Population Health Research Data Repository housed at the Manitoba Centre for Health Policy, University of Manitoba and were derived from data provided by MHHLS, as well as CancerCare Manitoba, the Winnipeg Regional Health Authority, and the Vital Statistics Agency. Strict policies and procedures were followed in producing this report to protect the privacy and security of the Repository data.

ABOUT THE MANITOBA CENTRE FOR HEALTH POLICY

The Manitoba Centre for Health Policy (MCHP) is located within the Department of Community Health Sciences, College of Medicine, Faculty of Health Sciences, University of Manitoba. The mission of MCHP is to provide accurate and timely information to healthcare decision–makers, analysts and providers, so they can offer services which are effective and efficient in maintaining and improving the health of Manitobans. Our researchers rely upon the unique Population Health Research Data Repository (Repository) to describe and explain patterns of care and profiles of illness and to explore other factors that influence health, including income, education, employment, and social status. This Repository is unique in terms of its comprehensiveness, degree of integration, and orientation around an anonymized population registry.

Members of MCHP consult extensively with government officials, healthcare administrators, and clinicians to develop a research agenda that is topical and relevant. This strength, along with its rigorous academic standards, enables MCHP to contribute to the health policy process. MCHP undertakes several major research projects, such as this one, every year under contract to Manitoba Health, Healthy Living & Seniors. In addition, our researchers secure external funding by competing for research grants. We are widely published and internationally recognized. Further, our researchers collaborate with a number of highly respected scientists from Canada, the United States, Europe, and Australia.

We thank the University of Manitoba, Faculty of Health Sciences, College of Medicine, Health Research Ethics Board for their review of this project. MCHP complies with all legislative acts and regulations governing the protection and use of sensitive information. We implement strict policies and procedures to protect the privacy and security of anonymized data used to produce this report and we keep the provincial Health Information Privacy Committee informed of all work undertaken for Manitoba Health, Healthy Living & Seniors.





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ACRONYMS

ACG [®]	The Johns Hopkins Adjusted Clinical Group [®] Case–Mix System	
ADG®	Aggregated Diagnosis Group™	
AJCC	American Joint Committee on Cancer	
ADT	Admission, Discharge, Transfer	
AMI	Acute Myocardial Infarction	
ATC	Anatomical Therapeutic Chemical	
CCI	Canadian Classification of Health Interventions	
CHF	Congestive Heart Failure	
CLL	Chronic Lymphocytic Leukemia	
DA	Dissemination Area	
DPIN	Drug Program Information Network	
Dx	Diagnosis	
ED	Emergency Department	
EDIS	Emergency Department Information System	
GEE	Generalized Estimating Equation	
HR	Hazard Ratio	
ICD	International Classification of Diseases	
ICES	The Institute for Clinical Evaluative Sciences	
IDI	Integrated Discrimination Improvement	
MCHP	Manitoba Centre for Health Policy	
NAACCR	North American Association of Central Cancer Registries	
NPV	Negative Predictive Value	
NRI	Net Reclassification Improvement	
РСН	Personal Care Home	
PPV	Positive Predictive Value	
RMSE	Root Mean Square Error	
ROC	Receiver Operating Characteristic	
RR	Relative Rate OR Relative Risk	
RUB	Resource Utilization Band	
VIMO	Valid, Invalid, Missing, Outlier	

EXECUTIVE SUMMARY

Background

This study examined Manitoba Cancer Registry data for the period from 1984 to 2011. These data were recently acquired into the Population Health Research Data Repository (Repository) housed at the Manitoba Centre for Health Policy (MCHP). The Manitoba Cancer Registry data contain information about all incident cases of diagnosed cancer, including demographic variables (e.g., age, sex, residential postal code), cancer treatments and dates of treatment, tumour characteristics, and cancer stage at diagnosis.

The Manitoba Cancer Registry, like other cancer registries across Canada and internationally, was originally intended to be used for surveillance and cancer control initiatives. Other studies have linked Manitoba Cancer Registry data with a select number of administrative health data to conduct investigations about health and health service use in individuals with a cancer diagnosis. However, incorporating the Manitoba Cancer Registry data into the Repository housed at MCHP enables a broader range and scope of cancer–related investigations using linked administrative data, including those about the social determinants of health, comparative effectiveness of cancer treatments, and quality of care across the healthcare spectrum.

Objectives

The objectives were:

- 1. To apply data quality evaluation tools developed at MCHP to the Manitoba Cancer Registry data to assess fitness of these data for cancer–related research involving linked data in the Repository;
- 2. To investigate additional measures of data quality that are relevant to the linkage of cancer registry and administrative data in the Repository; and
- 3. To conduct demonstration projects that link Manitoba Cancer Registry data to other administrative health data, allowing for new research opportunities.

Two demonstration projects, one with a policy focus and one with a methodological focus, were selected by researchers from CancerCare Manitoba and MCHP. The demonstration projects improved the skills of research team members in working with the de-identified, linked data, and generated new information about the Manitoba Cancer Registry to add to the MCHP Concept Dictionary, an on-line research tool that provides detailed operational definitions of variables or measures used in MCHP research.

The majority of the research focuses on the four leading cancers: breast, lung, prostate, and colorectal. However, we also investigated less prevalent cancers that were of interest to research team members, including bladder cancer and Chronic Lymphocytic Leukemia.

Methods

The MCHP Data Quality Framework, which is routinely applied to all new data acquired into the Repository, was applied to the Manitoba Cancer Registry data. A standardized set of analyses was conducted to examine such elements of data quality as completeness of data fields, internal consistency, and linkability of patient–identification variables in the Manitoba Cancer Registry with the corresponding variables in other administrative health data. We also investigated two data quality measures that are not in the MCHP Data Quality Framework, but provided additional insights about data quality: (a) agreement of postal codes recorded in the Manitoba Cancer Registry with postal codes recorded in other administrative data sources, and (b) validity of cancer diagnosis codes in hospital

and physician claims data when compared to diagnoses in the Manitoba Cancer Registry. Data quality was assessed via descriptive analyses of the percentages of valid, invalid, and missing observations, estimates of linear and non–linear trends to assess internal validity and consistency, kappa statistics to assess agreement, and estimates of sensitivity, specificity, and positive and negative predictive values to assess diagnostic validity.

The first demonstration project, which focused on emergency department (ED) use for adult patients with breast, colorectal, lung, or prostate cancer, involved the anonymized linkage of the Manitoba Cancer Registry data with Admission Discharge Transfer/E–triage and Emergency Department Information System data from the Winnipeg Regional Health Authority. The second demonstration project tested the predictive validity of several general–purpose measures of comorbidity, including the Chronic Disease Score, Charlson index, and Elixhauser index, for a variety of health and healthcare outcomes amongst individuals with a cancer diagnosis. Complete details of the methods used to conduct the demonstration projects can be found within the report.

Key Findings

The application of the MCHP Data Quality Framework to the Manitoba Cancer Registry data revealed a high degree of completeness of the data; there were very few data fields with missing or invalid observations, indicating that the data are thoroughly checked prior to release. Temporal consistency analyses revealed minimal variation in key data fields over time, suggesting a consistent data collection methodology. Cancer stage, which was not collected by CancerCare Manitoba until 2004, had some missing information because it is not possible to stage all cancers. There was also some loss of cancer treatment information in 2005; this was associated with a change in coding standards. However, there was 100% linkage of anonymized patient–specific identification variables in both the Manitoba Cancer Registry data and administrative data in the Repository.

Six-digit postal codes for residence location in the Manitoba Cancer Registry were in close agreement with the corresponding information found in both the provincial population registry and hospital records. Residence information is important for conducting geographic analyses.

Diagnosis codes for breast, prostate, colorectal, lung, and bladder cancers in hospital discharge abstracts and physician billing claims were compared to cancer diagnoses in the Manitoba Cancer Registry. Administrative data cancer diagnoses exhibited good to excellent validity. For example, when a one–month observation window before and after the cancer diagnosis was used to estimate diagnostic validity of administrative health data, sensitivity estimates ranged from 0.68 for prostate cancer to 0.89 for lung cancer. Validity increased as the size of the observation window increased from one month to six months, but changed little when it increased to 12 months. This data quality analysis is important for ascertaining cancer cohorts when access to Manitoba Cancer Registry data are not possible.

The demonstration projects provided the investigators with an in–depth understanding of the challenges and benefits associated with the anonymized linkage of Manitoba Cancer Registry data to administrative health data in the Repository housed at MCHP. Key findings from these projects can be found within the report.

Conclusions

Cancer registry data have multiple potential uses, beyond surveillance and cancer control, for investigating the health and healthcare use of individuals with a cancer diagnosis. When cancer registry data are linked with other administrative health data, for example, population–based cohorts can be constructed and used to investigate health outcomes and variations in healthcare use. The resulting analyses may assist in resource planning and delivery of cancer prevention and treatment services. As well, cancer registry data can be used to study the comparative effectiveness of population–based cancer prevention or treatment programs. Studies about the use of different healthcare system sectors and trajectories of care can facilitate quality of care studies and the seamless delivery of healthcare services.

The Manitoba Cancer Registry data undergo systematic quality evaluations prior to their integration into the Canadian Cancer Registry and in order to achieve certification from the North American Association of Central Cancer Registries. Thus, the data have very high quality. Application of the MCHP Data Quality Framework to these data produced standardized data quality documentation. This standardized information is essential for making quality comparisons across different data in the Repository housed at MCHP; it ensures that all researchers who use the Repository have comparative information about the characteristics of all types of administrative data.

The demonstration projects revealed the importance of having access to documentation and expertise with the Manitoba Cancer Registry data. As well, these projects highlight the benefits of working in collaborative teams to define research problems, develop appropriate methodologies, and interpret the study results.

Recommendations

Based on these findings and conclusions, the following recommendations arise from this study:

- 1. Ensure that research teams using Manitoba Cancer Registry data have access to expertise from both CancerCare Manitoba and MCHP.
- 2. Develop concepts on cancer-related project-specific data quality for the MCHP Concept Dictionary.
- 3. Incorporate additional CancerCare Manitoba data to strengthen cancer–related population health and health services research in Manitoba.
- 4. Undertake new MCHP deliverables and research projects that capitalize on the strengths of the Manitoba Cancer Registry data and the rich and diverse data resources available in the Repository.

CHAPTER 1: INTRODUCTION AND REVIEW OF LITERATURE

A cancer registry is a systematic collection of data about all new cancer cases; it is either facility–based (i.e., captures the population of a hospital) or population–based (i.e., captures the population of an entire geographic area) (World Health Organization (WHO), 1991). Registries are a valuable resource for cancer–focused health services research and health surveillance. They are routinely used for such purposes as investigating and reporting on trends and geographic variations in cancer incidence and mortality, and monitoring changes and differences in treatments across patient groups. Studies based solely on cancer registry data are limited to those variables that are routinely collected within the registry. While the number and type of variables will vary with the jurisdiction, generally they are limited to demographic variables (e.g., age, sex), cancer treatment types and dates of treatment, cancer characteristics (e.g., behaviour diagnostic confirmation), and cancer stage and prognostic information (e.g., summary stage).

Patient–specific linkage of cancer registries to other secondary data sources, including healthcare utilization and treatment data and behavioural risk factor data, creates a rich set of opportunities to expand the range and scope of studies that are conducted using cancer registry data. For example, studies about comparative effectiveness of cancer treatments and the costs and quality of care, are possible via linkage of cancer registration data with data from other sources (Chang, Su, & Lee, 2015; Roder et al., 2015). Data linkage can create valuable new insights about cancer risk factors and factors associated with variations in cancer treatment and care. These types of studies can inform cancer research and surveillance priority–setting exercises and assist decision makers with planning cancer control strategies. Linkage of cancer registry data to secondary data sources can also be used to evaluate the quality of data fields within a cancer registry and to ensure a high degree of completeness of case capture. These linkages are typically conducted using anonymized data, to ensure their confidentiality.

Each Canadian province and territory has a cancer registry that captures information about its entire population; the oldest registries were established in the 1930s in Saskatchewan and British Columbia. However, not all provinces have a legislated responsibility for cancer control. In provinces and territories without such legislation, cancer control is the responsibility of the Department of Health.

The Manitoba Cancer Registry, which is housed at CancerCare Manitoba, was established in 1956, although cancer information has been captured for the provincial population since the 1930s. The Manitoba registry captures all cases of cancer in the province identified at the time of biopsy, surgery, or hospital discharge; death certificates and autopsy records are also used to ascertain cancer cases. Registrars compile information about the characteristics of the patient, tumour, and treatment for inclusion in the registry. Given that cancer reporting is mandated by law in Manitoba, information on all potential new cases is reportable to the registrars of the Manitoba Cancer Registry (CancerCare Manitoba, 2015).

The Manitoba Cancer Registry data are a unique and valuable resource for research and surveillance. For example, Manitoba was the first Canadian province to begin capturing cancer stage information. The data collection system for stage was implemented for all cancers, excluding non-melanoma skin cancers, beginning in January 2004 (CancerCare Manitoba, 2010). The most widely used staging system, and the system used in Manitoba, is the TNM system of the American Joint Committee on Cancer (AJCC) (Edge & Compton, 2010). This system codes the extent of the primary tumour (T), regional lymph nodes (N), and distant metastases (M) and provides a stage grouping based on T, N, and M. TNM is not static; it changes based on new developments in cancer prognosis so that it can remain relevant to both clinicians and patients. The collection of population-level cancer stage data is a significant achievement for Manitoba and has a significant benefit to policy-relevant research. For example, when combined with data on treatment, cancer stage data can be used to assess whether healthcare for cancer patients is being delivered appropriately.

Manitoba is also recognized within Canada and internationally for its strong commitment to maintaining the quality of its cancer registry data. CancerCare Manitoba has been pro–active in data quality initiatives (Turner, Hildebrand, Fradette, & Latosinsky, 2007). Cancer data in Manitoba is reported to and certified by the North American Association of Central Cancer Registries (NAACCR) on an annual basis. At the time of this report preparation Manitoba held the Gold Standard for Registry Certification from NAACCR, which means that it has achieved the highest standard for complete, accurate, and timely data.

Deterministic, anonymized linkage of Manitoba Cancer Registry data to other data is achieved via a unique personal health identification number. The linkage of Registry data to such administrative data as hospital records, physician billing claims, and prescription drug records, has already enabled many cancer–focused population health and health services studies and reports (Holmes, Griffith, Musto, & Minuk, 2013; Singh, Nugent, Demers, & Bernstein, 2010). However, there is an even greater potential for policy–relevant cancer research by linking the Manitoba Cancer Registry to population–based health and social data at the Manitoba Centre for Health Policy (MCHP).

Linkage of cancer registry data to diverse types of administrative data has occurred in other provinces, as well as nationally and internationally. For example, the Institute for Clinical Evaluative Sciences (ICES) in Ontario has a data sharing agreement to link cancer registry data from Cancer Care Ontario to other types of administrative data. Multiple studies have been conducted with these linked data (Ho et al., 2011; Kelly et al., 2010; Margel et al., 2013). ICES and Cancer Care Ontario also established the Ontario Cancer Data Linkage Project, also known as "cd–link", which involves the linkage of cancer registry data to administrative health data and subsequent release of these data to researchers outside the secure environment of ICES (Earle, 2014). In cd–link data files, identifiers are removed or scrambled, and all dates that are more specific than year are converted to the number of days relative to the index date (e.g., diagnosis date). This step, along with other measures applied to the released data, ensures confidentiality of person–specific information and compliance with Ontario health privacy legislation while also reducing data access and analysis charges. This process improves the accessibility of the data to researchers.

Nationally, the Canadian Cancer Registry, which was established in 1992 as a collaborative venture between the provinces and territories and the Health Statistics Division of Statistics Canada, has been linked to both health–related and non–health–related secondary data (Statistics Canada, 2015). A recent national study linked 1991 Census microdata with administrative records from the Canadian Cancer Registry, Vital Statistics Registry, and longitudinal personal income tax records to estimate the effect of cancer on labour market outcomes amongst cancer survivors (Jeon, 2014). A cancer survivor cohort was compared to a non–cancer cohort on annual earnings and employment status for the three years following cancer diagnosis. While annual wages were lower for the cancer survivor group than the non–cancer group, the magnitude of the differences were not substantial. The study investigators concluded that a cancer diagnosis had a larger impact on employment status than on wages in the short–term. These national linked data have also been used to examine the association of occupation category with cancer incidence (Sritharan, 2014; Sritharan et al., 2014). Given that the Canadian Cancer Registry does not contain treatment information, current research is also examining the linkage to hospital discharge abstracts to facilitate national research on the characteristics and determinants of type of cancer treatment (Sanmartin, 2014).

Internationally, efforts to link cancer registry data with administrative health data have occurred in multiple countries. For example, in Australia's New South Wales region, cancer registry data were linked to hospital records to examine factors associated with facility–level variations in care and health outcomes for colorectal cancer patients (Jorgensen, Young, Dobbins, & Solomon, 2014). A broad strategy for linkage of cancer registry data to both administrative health data and population–based survey data is being implemented to facilitate health services research in Australia (Roder, Fong, Brown, Zalcberg, & Wainwright, 2014). In the United States, an initiative to link the National Cancer Institute's Surveillance, Epidemiology and End Results (SEER) data with Medicare beneficiary survey data will improve knowledge about cancer patients' self–reported experiences of care (Chawla et al., 2015).

Purpose and Objectives

The purpose of this deliverable was to incorporate the Manitoba Cancer Registry into the Repository housed at MCHP in order to establish a broad base for cancer research in Manitoba using linked administrative data. This deliverable is one of several deliverables conducted in recent years to provide an in–depth exploration of new data that are now routinely added to the Repository.

The research objectives were:

- 1. To apply data quality evaluation tools developed at MCHP to the Manitoba Cancer Registry data to assess fitness of these data for cancer–related research involving linked data in the Repository;
- 2. To investigate additional measures of data quality that are relevant to the linkage of cancer registry and administrative data in the Repository; and
- 3. To conduct demonstration projects that link Manitoba Cancer Registry data to other administrative health data, allowing for new research opportunities.

Two demonstration projects were selected by representatives from CancerCare Manitoba and MCHP. The first had a policy focus; it examined emergency department (ED) use amongst cancer patients. This was the first study in Manitoba to link de–identified Manitoba Cancer Registry data with ED data, and was undertaken to explore changes in ED use throughout the patient's cancer journey. The second demonstration project had a methodological focus; it examined the predictive validity of various comorbidity measures for cancer patient health outcomes, such as death and hospitalization. This demonstration project was undertaken to develop recommendations about the optimal measure(s) to adjust for the confounding effects of comorbidity in health outcome studies amongst individuals with cancer.

This deliverable was undertaken to provide MCHP researchers and analysts, as well as external investigators, with information about the attributes, strengths, and limitations of the Manitoba Cancer Registry data, to engage with individuals at CancerCare Manitoba who have expertise in the collection, reporting, and use of the Manitoba Cancer Registry, and to establish collaborations that will benefit population health and health services research within the province.

Report Organization

This report has the following structure. Chapter 2 provides an overview of the MCHP Data Quality Framework and its uses for describing the quality of administrative health data that are added to the Repository. As well, this chapter examines previous research about cancer registry data quality and describes selected features of the Manitoba Cancer Registry data. This chapter also provides information about some new data quality measures that can be used to examine the relative advantage of using registry data instead of administrative health data, or vice versa, to examine the characteristics of cancer patients. In Chapters 3 and 4, the methods and findings for two demonstration projects involving the Manitoba Cancer Registry data are described. In the first demonstration project, the Manitoba Cancer Registry data were linked to ED records. The second demonstration project focuses on methods for measuring and characterizing comorbidity in cancer patients. Chapter 5 concludes with a summary of the key findings of this data–focused deliverable, and recommendations for research and quality evaluations using the Manitoba Cancer Registry data. Appendix 1 provides comprehensive details about the measures and methodologies used in this report.

CHAPTER 2: APPLYING MCHP'S DATA QUALITY FRAMEWORK TO THE MANITOBA CANCER REGISTRY

Introduction

An assessment of data quality is an essential component of any study involving secondary data. The MCHP Data Quality Framework was developed in 2012 after a thorough review of existing secondary data quality frameworks from such organizations as the Canadian Institute for Health Information, Statistics Canada, and Australian Bureau of Statistics. The MCHP Framework provides a standardized and routinized approach to evaluate the quality of administrative data in the Repository (Lix et al., 2012c). The Framework has two components: (a) data–specific quality, and (b) project–specific quality. The former focuses on data quality measures that can be produced with minimal linkages amongst the administrative data. The latter focuses on data quality measures that are investigated within a research project and require linkage of the de–identified data in the Repository. Data quality measures in the Framework have been operationalized via SAS macros (standardized statistical program code¹). For example, the VIMO macro produces information about the percentage of valid, invalid, missing, and outlying observations for each field in a dataset, while the TREND macro produces a fitted line or curve to a temporal data series to identify potential outliers. These macros are useful for exploring data quality at a high level, and for initiating conversations about potential challenges in the analysis and interpretation of the data.

Quality of Cancer Registry Data

Several dimensions of data quality in the MCHP Data Quality Framework are consistent with the dimensions identified as key elements of cancer registry data quality (see Figure 2.1). For example, Parkin and Bray identified the following key elements of cancer registry data quality: comparability, validity, completeness, and timeliness (Bray & Parkin, 2009; Parkin & Bray, 2009). Comparability refers to the extent to which cancer registry practices adhere to standard guidelines, enabling fair comparisons of the number of cancer cases across time and space. If data comparability cannot be achieved, then variations in the number of cancer cases may be a function of differences in data collection/capture methods, rather than a true reflection of the underlying health of a population. Validity is defined as the extent to which a cancer case possesses the attributes in individual cancer registry fields (e.g., type of cancer). Completeness reflects the degree to which all cancer cases are captured within a registry. Methods to ensure completeness of cancer registries include the use of multiple data sources to ascertain cases and legislation to ensure mandatory case reporting. For example, completeness can be evaluated by linking cancer registry data with other sources, such as clinical registries, to identify potentially missed cases. Dataset audits and chart abstractions can also be used to estimate completeness. Finally, timeliness is the degree to which data are upto-date and contain complete and accurate information. Sometimes there is a tradeoff between timeliness and accuracy or completeness. Components of timeliness include the duration of time from diagnosis to receipt of a report of a cancer case by a registrar, and processing time, defined as the time from receipt of the report of a cancer case to data availability.

¹ Descriptions and technical details of all macros used in the MCHP Data Quality Framework are available on the MCHP website http://umanitoba.ca/faculties/health_sciences/medicine/units/ community_health_sciences/departmental_units/mchp/ resources/repository/dataquality.html

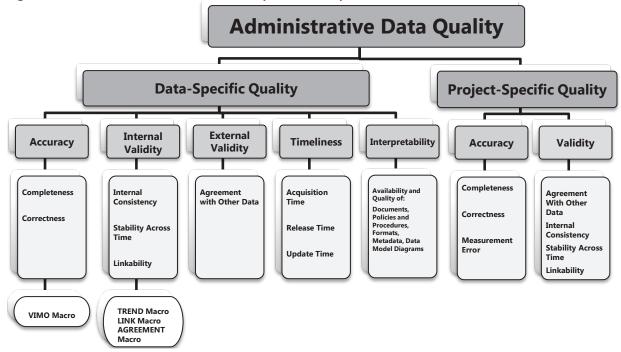


Figure 2.1: Manitoba Centre for Health Policy Data Quality Framework

Source: Lix LM, Smith M, Azimaee.M., et al. A Systematic Investigation of Manitoba's Provincial Laboratory Data. Manitoba Centre for Health Policy. December, 2012. http://mchp-appserv.cpe.umanitoba.ca/reference/cadham_report_WEB.pdf. Accessed May 29, 2013.

A number of factors may contribute to less-than-optimal quality of cancer registry data. These include registrar expertise in collecting and recording data, consistent and timely access to the data sources used to ascertain cancer cases, and the availability of resources (e.g., financial, human) to support data quality evaluation initiatives. As well, resources must be available to ensure that data sources used to ascertain cancer cases are of good quality.

The Canadian Cancer Registry provides annual reports to the provinces and territories about the quality of their data (Marion, Thomas, & Statistics Canada, 2004; Statistics Canada, 2015). The reports contain multiple indicators of the quality of both patient and tumour data. While capture of malignant tumours is generally quite high because of provincial/territorial legislation that mandates reporting, a lack of timeliness of provincial/territorial submissions to Statistics Canada may affect evaluations of data quality (Statistics Canada, 2015).

The Manitoba Cancer Registry is well known as a source of high–quality cancer registration information (Fradette, Lu, Dewar, & Turner, 2011). For example, in an examination of cases registered from 1991 to 1995, the NAACCR estimated the Manitoba Cancer Registry was 95% to 98% complete in ascertaining cancer cases, excluding non–malignant skin cancers (Chen, Wu, & Andrews, 1999).

In the US, Mallin et al. (2013) note that while the quality of cancer registry data for traditional functions, such as estimating incidence and describing trends in various population groups, is generally high, the data may not be of high quality for newer areas of interest, such as monitoring variations in treatment and care outcomes. This may necessitate new perspectives on data quality evaluation tools and methods in the future.

Summary of MCHP Data Quality Report for the Manitoba Cancer Registry

Appendix 2 contains tabled information from the data quality report produced by applying the MCHP Data Quality Framework to the Manitoba Cancer Registry^{2,3}. The report has the following standard sections: (a) overview, (b) accuracy, (c) linkability, and (d) internal validity. Three new sections were added to this report to further explore the internal validity of the data.

In terms of the overview section (Appendix Table 2.1), the report reveals that data from 1984 to 2011 are contained in a total of three datasets, but that there are two different types of datasets—registration and treatment. A total of 35 fields are contained in these datasets.

The accuracy section (Appendix Tables 2.2 and 2.6, and Figures 2.1–2.2) contains the results of analyses that result from applying the VIMO macro to the Manitoba Cancer Registry data. Accuracy is evaluated for different types of variables: identification, date, numeric, and character. For character variables, the specific values found in the data are included in the report; this allows the reader to easily check for implausible values.

The results in the accuracy section revealed that the vast majority of data fields were complete; those that were incomplete were related to cancer stage (i.e., AJCC stage variables). Information about cancer stage was only added to the Manitoba Cancer Registry in 2004, which explains, in part, why some fields have missing data.

Appendix Tables 2.3, 2.4, and 2.5 provide further details; they contain cancer stage data in the Manitoba Cancer Registry from 2004 until 2011, by cancer site. Table 2.3 contains the stage data from 2004–2009, which were reported using the 6th edition of AJCC, while Table 2.4 contains the stage data from 2010–2011 using the 7th edition of AJCC, which was implemented in 2010. For these two time periods, a similar percentage of the T (tumour), N (lymph node), and M (metastasis) variables are unknown (approximately 10%), meaning that stage cannot be assessed. For the same two time periods, a similar percentage of the T, N, and M variables are missing data (approximately 25%), which arises because some cancers by their nature cannot be staged. Table 2.5 captures summary stage information for the two time periods by cancer site; it demonstrates that over time, missing data were always limited to cancer sites other than the four major sites of breast, colorectal, lung, and prostate.

Other information in the VIMO table (Appendix Table 2.2) in the accuracy section reveals a maximum age at diagnosis of 109 years and a minimum age of 0 years; these extreme values represent potential outliers that could be examined further to ensure their accuracy. Some treatment information was also missing (see Appendix Table 2.2). Missing data are associated with a change in coding systems from the International Classification of Diseases version 9 (ICD–9) to ICD 10 in 2005; this is noted for the CCI variable, which contains the intervention codes from the Canadian Classification of Interventions (CCI) and the TXICD9 variable, which contains procedure codes from ICD–9. The change in coding from ICD–9 to CCI in the cancer registry data closely parallels the change in coding from ICD–9. To ICD–10 in 2005; fiscal year in Manitoba. In the VIMO table for the accuracy section, it should be noted that the treatment date has two invalid values, both of which occurred after 2011. Note that the VIMO assessment results are provided in both tabular and graphic formats; the latter provides the percentages of valid, invalid, missing, and outlier observations.

Information about the linkability of patient–specific identification variables is also provided (see Appendix Table 2.7). In both datasets, this ID variable has 100% linkage capability, indicating that all individuals in the Manitoba Cancer Registry could potentially be found in the Manitoba Health Insurance Registry, and vice versa.

² Descriptions of the Manitoba cancer registry and all other data used in this report can be found on the MCHP website http:// umanitoba.ca/faculties/medicine/units/community_health_sciences/departmental_units/mchp/_resources/repository/datalist. html

³ All data management, programming and analyses in this report were performed using SAS® version 9.3

The internal validity section, which contains results in graphic format, pertains to diagnosis date and treatment date (see Appendix Figures 2.3 and 2.4). The analysis of the former variable indicates that the frequency of records containing diagnosis date is increasing over time. There are two outlier values in the analysis of frequency of records by year, based on a fitted line (shown as a dashed line). With respect to the internal validity of treatment date, the frequency of records containing the treatment date has increased over time, except in 2005 (outlier value), when there was a sharp drop due to a loss of treatment information associated with the change in coding standards.

Additional data consistency checks are reported in Appendix Table 2.9. These pertain to some issues with treatment dates.

One customized, supplementary data quality evaluation was used to describe the distribution of treatment data by month and year (Appendix Table 2.10). The analyses reveal a non–uniform distribution. Consultations with Manitoba Cancer Registry analysts and epidemiologists revealed that only the first round of chemotherapy treatment in a given year is recorded in Manitoba Cancer Registry data, regardless of the number of rounds that are received in a calendar year. The treatment date status variable is used to interpret completeness of the date of treatment. This field will contain a "c" if the date is complete, "m" if the date is complete only to the month level, and "y" if the date is complete only to the year level. If the date of the first chemotherapy session is unknown, then it is recorded as occurring in January. This will account for the higher frequency of treatment dates in January for each of the interrogated years.

A second supplementary data quality evaluation was conducted using the frequency distribution of cancer sites by sex (Appendix Table 2.11). The results demonstrate expected patterns, such as few breast cancers amongst men.

Measuring Other Elements of Data Quality of the Manitoba Cancer Registry

After applying the MCHP Data Quality Framework to the Manitoba Cancer Registry and exploring the data fields in both the registry and treatment datasets, we investigated the following additional measures of data quality to better understand the comparability of the Manitoba Cancer Registry data and the administrative health data: (a) agreement of residence location between the Manitoba Cancer Registry and administrative health data, and (b) validity of cancer diagnoses in administrative health data using the Manitoba Cancer Registry as the reference data source. The methods and results are provided below for each of these quality measures.

Location of Residence Agreement

Assigning accurate locations of residence for cancer patients is important to ensure unbiased results for studies about the association between geography and health or healthcare use. Previous research has shown, for example, that rural cancer patients are more likely to die in hospital than urban cancer patients, despite the preference amongst the majority of cancer patients to die at home (Burge, Lawson, & Johnston, 2005). An inability to accurately assign one's residence location could lead to misclassification of urban and rural residents.

We examined the agreement between postal code recorded in the Manitoba Cancer Registry and the corresponding information in the Manitoba Health Insurance Registry and Hospital Abstract Data⁴. The Manitoba Health Insurance Registry contains dates of health insurance coverage and demographic information such as date of birth, sex, and six–digit postal code. Hospital discharge abstracts, which capture all inpatient hospitalizations, also contain six–digit postal code.

For Manitoba Cancer Registry data from 1984 to 2011, we compared the cancer patient's postal code at the time of diagnosis to: (a) the postal code in the Manitoba Health Insurance Registry on the same date, where the date of diagnosis was within the start and end dates of health insurance coverage, and (b) the postal code recorded on any

⁴ Additional information about all indicators and measures used in this report can be found in Appendix 1.

hospital discharge abstract that had a date of hospital separation within 90 days of the cancer diagnosis date. For patients with multiple cancers, only the first cancer diagnosis was used to conduct the analysis. This analysis was conducted for all cancer patients.

Agreement was estimated using the kappa (κ) statistic. The interpretation of κ adopted in this analysis was: $\kappa < 0.20$ is poor agreement, $0.20 \le \kappa \le 0.39$ is fair agreement, $0.40 \le \kappa \le 0.59$ is moderate agreement, $0.60 \le \kappa \le 0.79$ is good agreement, and $\kappa \ge 0.80$ is very good agreement (Altman, 1990). Analyses were stratified by age group (< 40 years, 40–64 years, 65+ years) because geographic mobility tends to be higher amongst younger than older age groups.

The results are reported in Table 2.1. Overall agreement was very good and was similar for both the Manitoba Health Insurance Registry and Hospital Abstract Data. When the results were stratified by age group, agreement was observed to be high and similar for the two oldest age groups, and lower for the youngest age group. For the youngest age group, agreement was higher for hospital discharge abstracts than for the Manitoba Health Insurance Registry, where only good agreement was observed.

Age Group (years)	Data Source Kappa (95% Confidence Interval)		
(years)	Manitoba Health	Hospital	
	Insurance Registry	Abstract Data	
Under 40	0.72 (0.72, 0.73)	0.81 (0.80, 0.81)	
40-64	0.86 (0.86, 0.87)	0.88 (0.88, 0.89)	
65+	0.87 (0.87, 0.87)	0.89 (0.89, 0.89)	
Overall	0.86 (0.85, 0.86)	0.88 (0.88, 0.88)	

Table 2.1: Estimates of Agreement (Kappa) for Six-Digit Postal Code Recorded in the Manitoba Cancer Registry and Other Administrative Data Sources

Validity of Cancer Diagnoses in Administrative Health Data

The Manitoba Cancer Registry is recognized as an unbiased source of information for ascertaining cancer cases. We examined the accuracy of cancer diagnoses recorded in hospital discharge abstracts and physician billing claims when compared to the Manitoba Cancer Registry. This analysis was undertaken for the period from April 1, 1997 to March 31, 2011. Individuals were identified as cancer cases in administrative health data if they had at least one hospital abstract or one physician billing claim with the relevant cancer diagnosis within one month, six months, and one year (before or after) the cancer diagnosis date in the Manitoba Cancer Registry. The following cancer sites were included: bladder, breast, colorectal, lung, and prostate.

The following statistics were estimated for each cancer site: sensitivity, specificity, positive predictive value (PPV), negative predictive value (NPV), and kappa (κ). The interpretation of κ adopted for this analysis was: $\kappa < 0.20$ is poor agreement, $0.20 \le \kappa \le 0.39$ is fair agreement, $0.40 \le \kappa \le 0.59$ is moderate agreement, $0.60 \le \kappa \le 0.79$ is good agreement, and $\kappa \ge 0.80$ is very good agreement (Altman, 1990). The Wilson score interval method was used to calculate the 95% confidence interval for all statistics except for κ ; for this latter statistic, an asymptotic 95% confidence interval was used.

The results are shown in Table 2.2. When we used a one–month observation window, that is, when we considered the period from one month before to one month after the cancer diagnosis to estimate diagnostic validity, sensitivity estimates ranged from 0.69 for prostate cancer to 0.89 for lung cancer. Specificity attained its upper bound of 1.00 for all cancers. PPV values were below 0.99 for bladder cancer only. Kappa estimates ranged from 0.77 (good agreement) for prostate cancer to 0.92 (very good agreement) for lung cancer.

Diagnostic validity improved when a six–month observation window was used, that is, when we considered the period from six months before to six months after the cancer diagnosis to estimate diagnostic validity. For prostate cancer, sensitivity increased to 0.95. Sensitivity was lowest for bladder cancer (0.92). PPV was also lowest for bladder cancer (0.84), and was highest for breast cancer (0.98). Kappa estimates showed very good agreement for all cancers, and ranged from 0.87 for bladder cancer to 0.97 for breast cancer.

There was almost no change in the estimates when a 12–month observation window was used, that is, when we considered the period from 365 days before to 365 days after the cancer diagnosis. Furthermore, in a sensitivity analysis we found that the validity estimates did not vary by cancer stage (data not shown).

Cancer Validation Measures (95% Confidence Interval)					
Site	Sensitivity	Specificity	Positive	Negative	Карра
			Predictive Value	Predictive Value	Kabba
1 month bef	1 month before and after cancer diagnosis				
Bladder	0.72 (0.69, 0.74)	1.00 (1.00, 1.00)	0.89 (0.87, 0.91)	0.99 (0.99, 0.99)	0.79 (0.77, 0.81)
Breast	0.87 (0.86, 0.87)	1.00 (1.00, 1.00)	0.99 (0.99, 0.99)	0.96 (0.96, 0.96)	0.90 (0.90, 0.91)
Colorectal	0.86 (0.86, 0.87)	1.00 (1.00, 1.00)	0.99 (0.99, 0.99)	0.96 (0.96, 0.96)	0.90 (0.89, 0.91)
Lung	0.89 (0.89, 0.90)	1.00 (0.99, 1.00)	0.99 (0.98, 0.99)	0.96 (0.96, 0.97)	0.92 (0.91, 0.92)
Prostate	0.69 (0.68, 0.70)	1.00 (1.00, 1.00)	0.99 (0.98, 0.99)	0.92 (0.92, 0.92)	0.77 (0.77, 0.78)
6 months be	fore and after cance	er diagnosis			
Bladder	0.92 (0.90, 0.93)	0.99 (0.99, 0.99)	0.84 (0.82, 0.86)	1.00 (1.00, 1.00)	0.87 (0.86, 0.89)
Breast	0.98 (0.98, 0.98)	0.99 (0.99, 0.99)	0.98 (0.97, 0.98)	0.99 (0.99, 0.99)	0.97 (0.97, 0.97)
Colorectal	0.96 (0.95, 0.96)	0.99 (0.99, 0.99)	0.97 (0.97, 0.98)	0.99 (0.99, 0.99)	0.96 (0.95, 0.96)
Lung	0.96 (0.96, 0.97)	0.99 (0.99, 0.99)	0.97 (0.97, 0.97)	0.99 (0.99, 0.99)	0.96 (0.95, 0.96)
Prostate	0.95 (0.95, 0.96)	0.99 (0.99, 0.99)	0.97 (0.97, 0.98)	0.99 (0.99, 0.99)	0.95 (0.95, 0.95)
1 year befor	1 year before and after cancer diagnosis				
Bladder	0.93 (0.92, 0.95)	0.99 (0.99, 0.99)	0.81 (0.79, 0.83)	1.00 (1.00, 1.00)	0.86 (0.85, 0.87)
Breast	0.98 (0.98, 0.99)	0.99 (0.99, 0.99)	0.97 (0.96, 0.97)	0.99 (0.99, 1.00)	0.97 (0.96, 0.97)
Colorectal	0.96 (0.96, 0.97)	0.99 (0.99, 0.99)	0.96 (0.96, 0.97)	0.99 (0.99, 0.99)	0.95 (0.95, 0.95)
Lung	0.97 (0.97, 0.97)	0.99 (0.98, 0.99)	0.96 (0.96, 0.96)	0.99 (0.99, 0.99)	0.95 (0.95, 0.96)
Prostate	0.97 (0.96, 0.97)	0.99 (0.99, 0.99)	0.96 (0.96, 0.97)	0.99 (0.99, 0.99)	0.95 (0.95, 0.96)

 Table 2.2: Validation Measures for Cancer Diagnoses in Administrative Data

 By cancer site and time period, 1997/98–2010/11

Conclusions

This chapter examined the quality of the Manitoba Cancer Registry data from the perspective of its use in the Repository housed at MCHP. Previous research has demonstrated the accuracy and completeness of the Manitoba Cancer Registry for purposes of cancer surveillance and research activities. The focus of this assessment was on its quality for linkage and in comparison to other administrative health data that might be used for cancer –focused population health and health services research. Only one previous Manitoba study has compared cancer registry and administrative health data; this study found that while the former was the optimal source of information for capturing treatment information for breast cancer patients, hospital discharge abstracts and physician billing claims also had highly accurate information (Turner et al., 2007).

Our research demonstrated that Manitoba Cancer Registry records can be linked to administrative health data with 100% agreement at the individual level, which means that linkage of the two sources of data does not result in

biases in capture of all individuals with a cancer diagnosis. While the vast majority of fields in the Manitoba Cancer Registry were complete, incomplete cancer stage information was documented in earlier years of the Registry, as was some incomplete treatment information. At the same time, we emphasize that cancer stage represents a valuable resource in the Manitoba Cancer Registry, given that few other cancer registries contain stage information. Studies to evaluate the quality of the stage information are warranted, but may also be challenging given the need to identify a "gold standard" for validation purposes. For example, Brusselaers et al. (2015) validated TNM stage information in the Swedish Cancer Registry using pathology information collected for oesophageal cancer patients who had surgery.

Place of residence at the time of cancer diagnosis based on the six-digit postal code in the Manitoba Cancer Registry compared favorably with place of residence captured in the Manitoba Health Insurance Registry and Hospital Abstract Data. However, the Cancer Registry does not contain information on place of birth or residence location prior to cancer diagnosis, which limits the ability to use these data for epidemiologic studies about the effect of the physical environment on cancer onset. In contrast, the Manitoba Health Insurance Registry has been used to monitor residential mobility and longitudinal changes in geographic location of residence for individuals with a chronic health condition (Lix et al., 2007). The Manitoba Health Insurance Registry is updated every six months with information provided by the provincial ministry of health.

Finally, the Manitoba Cancer Registry is the preferred source for ascertaining diagnosed cases of cancer in Manitoba. However, our study demonstrated that individuals who do not have access to the Manitoba Cancer Registry can accurately ascertain cases from hospital records and physician billing claims for the specific cancers investigated in this research.

As we noted at the outset of this chapter, the MCHP Data Quality Framework distinguishes between project–specific data quality and data–specific quality; the latter was the primary focus of this chapter. There are a number of other characteristics of the Manitoba Cancer Registry that could be investigated in future project– specific data quality investigations. For example, Warner et al. (2015) recently investigated the utility of text mining tools applied to electronic medical records to extract information on cancer stage. If this approach was validated in Manitoba, it could be used to retrospectively fill in stage information that is incomplete in the Manitoba Cancer Registry. As well, Lix et al. (2012a) validated surgical information in administrative data using the corresponding information in the Alberta Cancer Registry, demonstrating that the former are a valid data source. Thus, there are multiple opportunities for research that takes advantage of the linkage between Manitoba Cancer Registry data and administrative health data.

CHAPTER 3: DEMONSTRATION PROJECT 1: EMERGENCY DEPARTMENT USE IN CANCER PATIENTS

Introduction

The journey of a cancer patient through the healthcare system is often complex, and may involve emergency, acute, primary, supportive, rehabilitative, or palliative care sectors in addition to the cancer care sector (Elliss-Brookes et al., 2012). Not all patients will have the same pathway through the healthcare system; differences may be a function of patient characteristics, such as age and the presence of comorbid conditions, specific cancer and treatment factors, as well as system characteristics, such as the availability of end-of-life care.

Emergency department (ED) use, which is common amongst cancer patients, may also be a potential indicator of limited access to primary care or lack of continuity of care amongst healthcare providers (Burge, Lawson, & Johnston, 2003). Enright et al. (2015) and Kotajima et al. (2014) found that amongst lung cancer patients there were frequent visits to the ED for both cancer-related and cancer-unrelated issues following cancer diagnosis; the former included non-specific respiratory symptoms, pain, gastrointestinal and neurological issues, and fever, while the latter included infections, and cardiovascular and gastrointestinal conditions. Some studies have focused on ED visits at specific points in the cancer patient pathway, such as immediately prior to cancer diagnosis or near the end of life, in order to best characterize the patient's journey through the healthcare system. Barbera et al. (2010) reported that visits near the end of life for all cancer patients often occurred for such reasons as pain and respiratory issues. The authors proposed that by improving continuity of care and other healthcare sector-specific interventions, ED use could be reduced amongst cancer patients. In fact, Burge et al. (2003) found that increased continuity of care with family physicians was associated with reduced use of the ED in Nova Scotia. Elliss–Brookes et al. (2012) examined different healthcare pathways that cancer patients may take in order to be diagnosed with cancer. Patients for whom the pathway to diagnosis involved the ED had a lower one-year survival rate than patients who did not have a diagnosis pathway that included the ED.

Purpose and Objectives

The purpose of this demonstration project was to investigate ED use amongst individuals with a cancer diagnosis in Winnipeg, Manitoba. The objectives were to:

- Test for differences in ED use before and after cancer diagnosis,
- Describe reasons for ED use, and
- Examine the association of ED use with cancer cohort survival.

Methods

Data sources included the Manitoba Cancer Registry, the Manitoba Health Insurance Registry of individuals insured for health services in the population, Hospital Abstract data, physician billing claims from the Medical Services data, prescription drug dispensation records from the Drug Program Information Network (DPIN) data, area-level income from the Canada Census data, emergency department records from the Admission Discharge Transfer (ADT)/E-triage data and the Emergency Department Information System (EDIS) data. All data are contained in the Repository housed at MCHP⁵. Information about the Manitoba cancer registry and methods used in the analysis are provided in Appendix 1.

⁵ Descriptions of the Manitoba Cancer Registry and other data used in this report can be found on the MCHP website http:// umanitoba.ca/faculties/medicine/units/community_health_sciences/ departmental_units/mchp/resources/repository/datalist. html

The Manitoba Cancer Registry was used to identify the study cohorts. The population registry was used to ascertain health insurance coverage, socio-demographic characteristics of cancer patients, and date of death (based on the health insurance coverage cancellation code for death). Hospital discharge abstracts, physician billing claims, and prescription drug dispensation records were used to measure comorbidity and healthcare use. ED visits were found in ADT/E-Triage and EDIS data. There is the potential for overlap in the records contained in these two systems; therefore, ED data from January 1, 2006 to March 31, 2009 were taken from the ADT/E-Triage data, and ED data from April 1, 2009 to March 31, 2013 were taken from the EDIS data to avoid double-counting of visits. Both systems were used to measure ED use and reasons for ED use (i.e., chief complaint upon presentation to the ED). The Statistics Canada Census data were used to measure income quintile of the study cohorts.

The cancer cohort comprised all adults (18 years of age and older at the date of cancer diagnosis), diagnosed in the calendar years 2007 to 2010, inclusive. The cancer cohort was stratified by type of cancer (breast [n=1,555], colorectal [n=1,327], lung [n=1,437], and prostate [n=1,250]). If an individual had more than one type of cancer diagnosed in the observation period, then that individual was excluded from the study. The cancer cohort was matched 1:1 to a cohort of cancer-free individuals on age (5-year groupings beginning with 18–24 years), sex, and Charlson index score for comorbidity (0, 1, 2, 3+) (Charlson, Pompei, Ales, & MacKenzie, 1987). The date of diagnosis for individuals in the cancer cohort was assigned to individuals in the matched cancer-free cohort as their index date. The cancer cohort and the matched cancer-free cohort members who did not have a minimum of one year of health insurance coverage before the index date were excluded from the study. For the final objective, which examined the association of ED use with cancer survival, the cohort was selected using the same criteria as those for the first two objectives, except that the data used for the selection process were from 2007 to 2011.

For the first objective, to test for differences in ED use before and after cancer diagnosis, we counted the number of ED visits in monthly increments for the pre-diagnosis period, which extended from 12 months to two months prior to diagnosis, the peri-diagnosis period, which extended from one month before to one month after diagnosis, and the post-diagnosis period, which extended from two months to 24 months after diagnosis. As well, crude rates of ED use during office hour and non-office hour time segments were calculated for each time period. Individuals were followed up to two years after cancer diagnosis, or until they died, moved out of province, or until the end of the observation period of March 31, 2013, whichever came first. Generalized linear models with generalized estimating equations (GEEs) and a Poisson distribution were used to test for differences in ED use as follows: (a) differences amongst the pre-diagnosis, peri-diagnosis and post-diagnosis periods for the cancer cohort, (b) differences between the cancer cohort and matched cancer-free cohort for the entire study period, and (c) differences between the cancer cohort and matched cancer-free cohort for each of the pre-diagnosis, peri-diagnosis, and post-diagnosis periods. Generalized linear models with GEEs were used to account for clustering of visits within individuals over time. An autoregressive correlation structure was assumed for the repeated measurements. Crude rates of ED use during office hour and non-office hour time segments were compared using unadjusted Poisson regression.

The generalized linear models included the following covariates: cohort (i.e., cancer cohort or matched cancer-free cohort, where applicable), number of months since diagnosis, diagnosis period, a two-way interaction between cohort and diagnosis period (in models that were applied to the data for both cohorts), age group, sex (except for prostate cancer), income quintile, Charlson index score category, majority of ambulatory care, number of ambulatory physician visits, number of inpatient hospitalizations, and number of prescription dispensations. The model offset was the number of person-days of follow-up. Generalized linear models applied to data for the cancer cohorts only also included cancer stage and treatment variables, i.e., dichotomous indicators for occurrence of chemotherapy, radiation therapy, hormone therapy (for breast and prostate sites only) and surgical intervention. Relative rates (RRs) along with 95% confidence intervals are reported for all models.

Income quintile was assigned based on an individual's residence (i.e., postal code) as of the index date, while comorbidity was measured for the one-year period prior to the index date. The income quintiles had six levels: Q1 (lowest), Q2, Q3, Q4, Q5 (highest), and income information not available. The measurement of majority of ambulatory care was made using a binary indicator for whether an individual had more than 75% of their in-office physician visits to the same provider (general practitioner, or internal medicine specialist for age 65 or older) in the year before and up to two years after diagnosis. Healthcare use variables were included in all models as time-varying covariates. Specifically, counts of the number of healthcare contacts were made in one-month increments for the one-year period prior to and up to two years after the index date. Office hours extended from 8 a.m. to 5 p.m. on weekdays (e.g., Monday to Friday), while non-office hours extended from 5 p.m. to 8 a.m. on weekdays, as well as all day on weekends and statutory holidays.

For the second objective, to describe reasons for ED use, we analyzed information about the patients' presenting complaint in the ADT/E-triage and EDIS data. The presenting complaint is collected via a standardized list (see Appendix 1). The complaints were grouped into categories based on anatomical site and severity of illness. Rates of ED visits for the most frequent complaint categories for the cancer cohort are presented by type of cancer for the pre-diagnosis period, peri-diagnosis period, and post-diagnosis period. Corresponding rates for the same complaint categories are presented for the matched cohort. Unadjusted Poisson regression models were used to test for differences in the rates of ED visits for different presenting complaints between the cancer cohort and the matched cancer-free cohort.

To achieve the third objective, examining the association of ED use with mortality, we followed cancer patients from the date of diagnosis until death, loss of health insurance coverage due to migration, or the end of the observation period of March 31, 2013, whichever came first. Multivariable Cox proportional hazards regression models were used to model time to death, stratified by type of cancer. Adjusted hazard ratios (HRs) were calculated to estimate the change in risk of death per increase in ED and other healthcare use. The covariates were age, sex, summary cancer stage, income quintile, comorbidity, number of ambulatory visits, number of inpatient hospitalizations, number of prescription drug dispensations, and number of ED visits. Income guintile was assigned based on an individual's residence (i.e., postal code) as of the index date, while comorbidity was measured using the Charlson index for the one-year period prior to the index date. Healthcare use (counts of physician visits, hospitalizations, prescriptions, and ED visits) were included in the regression models as baseline covariates for the year prior to index date, as well as time-varying covariates capturing use in each six-month interval or portion thereof in the follow-up period. Note that for this objective, covariates were included in the regression model as either baseline (up to one year pre-diagnosis) or time-varying (post-diagnosis) rather than pre-, peri- and post-diagnosis. This is because the risk of death after cancer diagnosis was assessed in a proportional hazards regression model, where time to death was the outcome, thus "time period" could not be included in the model as a parameter. The relative importance of ED use was assessed using a likelihood ratio test for nested models (i.e., models with and without the ED use variables).

Results

Objective 1: Emergency Department Use in the Pre-, Peri-, and Post-Diagnosis Periods

Breast Cancer

As shown in Figure 3.1, there was an increase in crude rates of ED use by the breast cancer cohort relative to the matched cancer-free cohort that began approximately one month prior to diagnosis and continued for approximately nine months. After adjusting for confounding covariates (Table 3.1 at the end of this section and Appendix Table 3.1), there was no statistically significant difference in ED use between the cancer cohort and the matched cancer-free cohort in the pre-diagnosis period (RR = 1.11, p = 0.5089). However, there was a statistically significant difference in the post-diagnosis period (RR = 1.74, p = 0.0001) and the post-diagnosis period (RR = 1.45, p < 0.0001).

We also examined crude rates of ED use stratified by cancer stage (Figure 3.2). Due to the relatively small number of cohort members in many of the stages, we showed rates of ED use for the combined group of individuals in stages 1 and 2, and the combined group of individuals in stages 3 and 4. After adjusting for confounding covariates (Table 3.1 in this section and Appendix Table 3.5), individuals in stage 3-4 had significantly lower pre-diagnosis ED use than individuals in stage 1-2. However, following this period, stage 3-4 individuals had significantly higher rates of ED use in the peri- and post-diagnosis periods, compared to individuals in stage 1-2. Rates of use for the stage 1-2 individuals were significantly higher in the post-diagnosis period than the pre-diagnosis period. For individuals in stage 3-4, the rates of use were significantly higher in both the peri- and post-diagnosis periods when compared with the pre-diagnosis period.

Figure 3.3 shows the crude rate of ED use in the breast cancer cohort and matched cancer-free cohort, stratified by office and non-office hour time segments within each of the pre-diagnosis, peri-diagnosis, and post-diagnosis periods. After adjusting for confounding covariates (Appendix Table 3.9), ED use during non-office hours was significantly higher than ED use in office hours in the pre-diagnosis period for the matched cancer-free cohort and in the post-diagnosis period for the breast cancer cohort.

Colorectal Cancer

Crude rates of ED use for the colorectal cancer cohort and matched cancer-free cohort are shown in Figure 3.4.

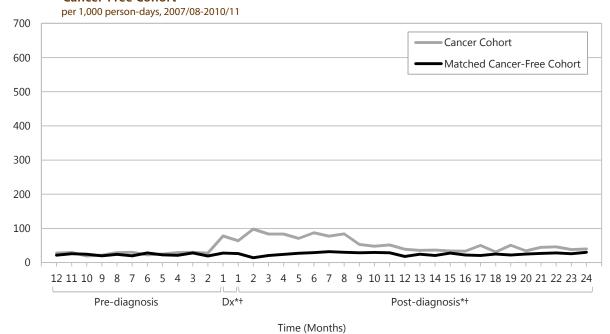


Figure 3.1: Crude Rates of Emergency Department Use for Breast Cancer Cohort and Matched Cancer-Free Cohort

 D_x indicates the peri-diagnosis period

* indicates a statistically significant difference in adjusted rates between the cohorts in this period (α =0.05)

+ indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for the cancer cohort (α =0.05)

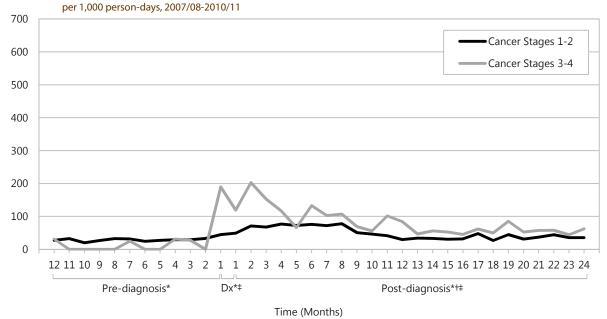


Figure 3.2: Crude Rates of Emergency Department Use for Breast Cancer Cohort by Cancer Stage

 D_{x} indicates the peri-diagnosis period

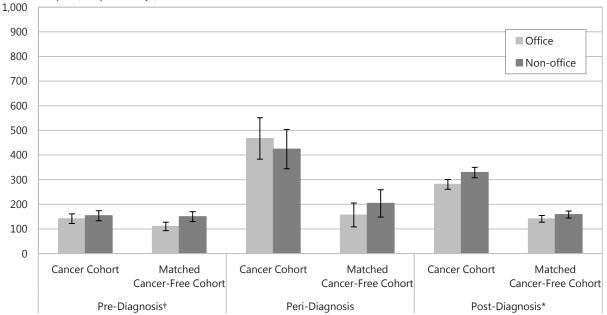
* indicates a statistically significant difference in adjusted rates between cancer stages in this period (α =0.05)

 \dagger indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for cancer stages 1-2 (α =0.05)

 \pm indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for cancer stages 3-4 (α =0.05)

Note: values suppressed due to small numbers are shown as zeroes





per 1,000 person-days, 2007/08-2010/11

Error bars indicate 95% confidence intervals

* indicates a statistically significant difference between rates in office and non-office hour time segments for the cancer cohort (α=0.05)

+ indicates a statistically significant difference between rates in office and non-office hours time segments for the matched cancer-free cohort (α=0.05)

Regression analyses (Table 3.1 and Appendix Table 3.2) indicate there was no statistically significant difference in ED use between the cancer cohort and the matched cancer-free cohort in the pre-diagnosis period (RR = 1.18, p = 0.1886). However, ED use was higher for the cancer cohort in the peri-diagnosis period (RR = 2.43, p < 0.0001) and the post-diagnosis period (RR = 1.44, p = 0.0005) when compared with the pre-diagnosis period.

ED use by cancer stage is presented in Figure 3.5. After adjusting for confounding covariates (Table 3.1 and Appendix Table 3.6), there was no significant difference in ED rates in the pre-diagnosis period between stage 1-2 and stage 3-4 individuals. In the peri- and post-diagnosis periods, individuals in stage 3-4 had significantly higher rates of ED use than individuals in stage 1-2. Both stage 1-2 and stage 3-4 individuals had significantly higher ED use in the peri- and post-diagnosis periods when compared with the pre-diagnosis period.

Figure 3.6 reports the crude rates of ED use amongst the colorectal cancer cohort and matched cancer-free cohort for office and non-office hour time segments for the pre-diagnosis, peri-diagnosis, and post-diagnosis periods. After adjusting for confounding covariates (Appendix Table 3.9), ED use in non-office hour segments was significantly higher than ED use in office hours in the post-diagnosis period for both the colorectal cancer cohort and matched cancer-free cohort.

Lung Cancer

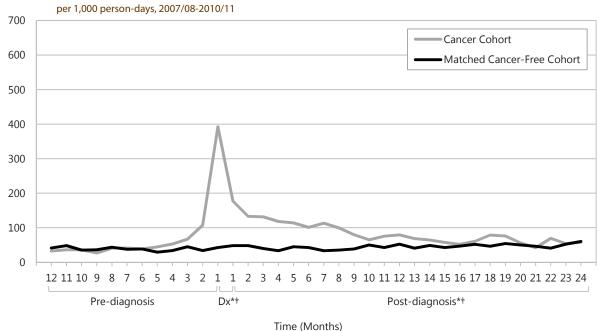


Figure 3.4: Crude Rates of Emergency Department Use for Colorectal Cancer Cohort and Matched Cancer-Free Cohort

D, indicates the peri-diagnosis period

* indicates a statistically significant difference in adjusted rates between the cohorts in this period (α =0.05)

+ indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for the cancer cohort (α=0.05)

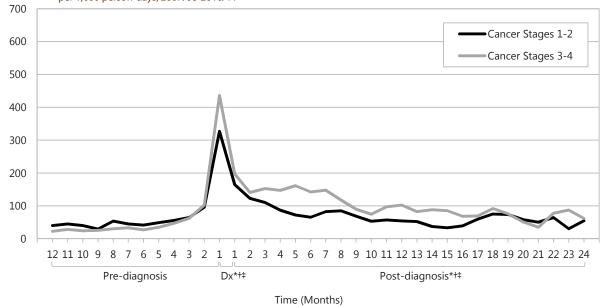


Figure 3.5: Crude Rates of Emergency Department Use for Colorectal Cancer Cohort by Cancer Stage per 1,000 person-days, 2007/08-2010/11

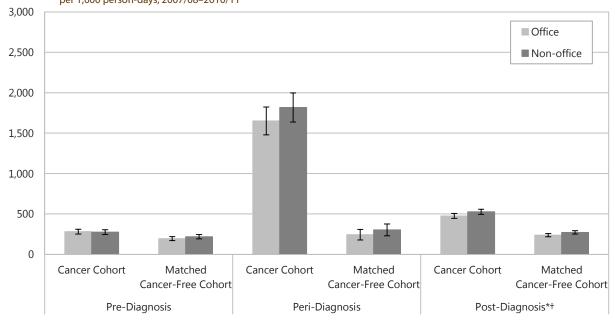
 D_{x} indicates the peri-diagnosis period

* indicates a statistically significant difference in adjusted rates between cancer stages in this period (α =0.05)

 \dagger indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for cancer stages 1-2 (α =0.05)

 \pm indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for cancer stages 3-4 (α =0.05)





Error bars indicate 95% confidence intervals

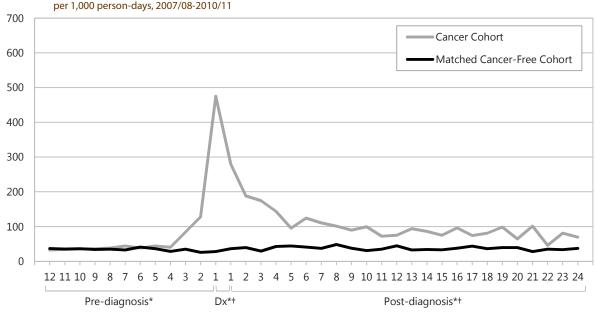
* indicates a statistically significant difference between rates in office and non-office hour time segments for the cancer cohort (α=0.05)

+ indicates a statistically significant difference between rates in office and non-office hours time segments for the matched cancer free cohort (α=0.05)

The lung cancer cohort exhibited a different pattern of ED use (Figure 3.7). Regression analyses (Table 3.1 and Appendix Table 3.3) indicated that, in addition to a sharp increase in ED use for the cancer cohort during the peri-diagnosis period (RR = 4.51, p < 0.0001), there was a statistically significant difference between the cancer and matched cancer-free cohorts in the pre-diagnosis period (RR = 1.38, p < 0.0001). It can be challenging to diagnose the symptoms of lung cancer, possibly leading to a longer period of ED use prior to diagnosis than for other cancers. In the post-diagnosis period, ED use was also significantly higher for the cancer cohort compared with the matched cancer-free cohort (RR = 2.28, p < 0.0001).

ED use by cancer stage is presented in Figure 3.8. After adjusting for confounding covariates (Table 3.1 and Appendix Table 3.7), there was no significant difference between stage 1-2 and stage 3-4 individuals in the pre-diagnosis period. In the peri- and post- diagnosis periods, individuals in stage 3-4 had significantly higher rates of ED use than individuals in stage 1-2. Both stage 1-2 and stage 3-4 individuals had significantly higher ED use in the peri- and post- diagnosis periods compared with the pre-diagnosis period.

Figure 3.9 shows the crude rates of ED use for the lung cancer cohort and matched cancer-free cohort during office and non-office hour time segments for the pre-diagnosis, peri-diagnosis and post-diagnosis periods. After adjusting for confounding covariates (Appendix Table 3.9), ED rates in the non-office hour time segments of the peri-diagnosis period were significantly lower than rates in office hour segments for the lung cancer cohort.



Time (Months)

Figure 3.7: Crude Rates of Emergency Department Use for Lung Cancer Cohort and Matched Cancer-Free Cohort

 D_{x} indicates the peri-diagnosis period

* indicates a statistically significant difference in adjusted rates between the cohorts in this period (α =0.05)

⁺ indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for the cancer cohort (α=0.05)

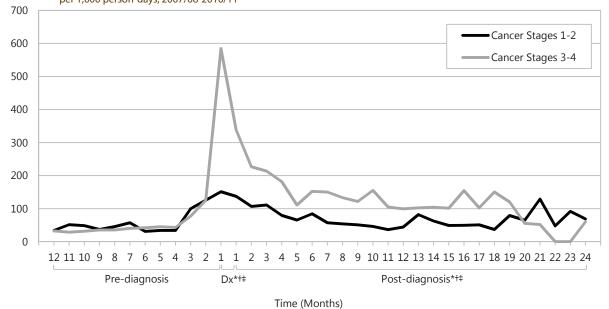


Figure 3.8: Crude Rates of Emergency Department Use for Lung Cancer Cohort by Cancer Stage per 1,000 person-days, 2007/08-2010/11

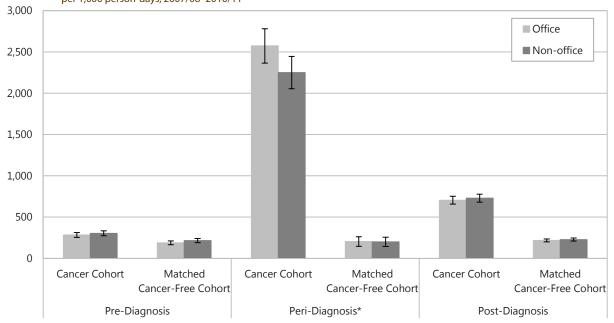
 D_{x} indicates the peri-diagnosis period

 * indicates a statistically significant difference in adjusted rates between cancer stages in this period (α =0.05)

 \dagger indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for cancer stages 1-2 (α =0.05)

 \pm indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for cancer stages 3-4 (α =0.05) Note: values suppressed due to small numbers are shown as zeroes





Error bars indicate 95% confidence intervals

* indicates a statistically significant difference between rates in office and non-office hour time segments for the cancer cohort (α =0.05)

+ indicates a statistically significant difference between rates in office and non-office hours time segments for the matched cancer-free cohort (α=0.05)

Prostate Cancer

Crude rates of ED use are shown for the prostate cancer cohort and matched cancer-free cohort in Figure 3.10. Regression analyses (Table 3.1 and Appendix Table 3.4) revealed a significant difference in ED use during the peri-diagnosis period between the cancer cohort and matched cancer-free cohort (RR = 3.10, p < 0.0001). However, there were no significant differences between the two groups in the pre-diagnosis period (RR = 1.14, p = 0.2157) or in the post-diagnosis period (RR = 1.20, p = 0.0842).

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ED use by cancer stage is presented in Figure 3.11. After adjusting for confounding covariates (Table 3.1 and Appendix Table 3.8), rates of ED use for individuals in stage 1-2 and stage 3-4 were not significantly different across time periods. However, individuals in both groups used the ED significantly more often in the peri-diagnosis period compared to the pre-diagnosis period.

Figure 3.12 shows the crude rate of ED use for the cancer cohort and the matched cancer-free cohort during office hour and non-office hour time segments during the pre-diagnosis, peri-diagnosis, and post-diagnosis periods. After adjusting for confounding covariates (Appendix Table 3.9), ED use in non-office hour time segments during the pre-diagnosis period were significantly higher than ED use in office hour segments only for the prostate cancer cohort. Rates in non-office hour segments were significantly higher than rates in office hour segments during the peri-diagnosis period for both cohorts.

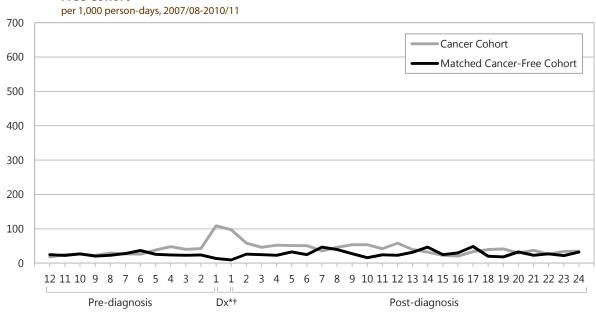


Figure 3.10: Crude Rates of Emergency Department Use for Prostate Cancer Cohort and Matched Cancer-Free Cohort

Time (Months)

D, indicates the peri-diagnosis period

* indicates a statistically significant difference in adjusted rates between the cohorts in this period (α =0.05)

+ indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for the cancer cohort (α =0.05)

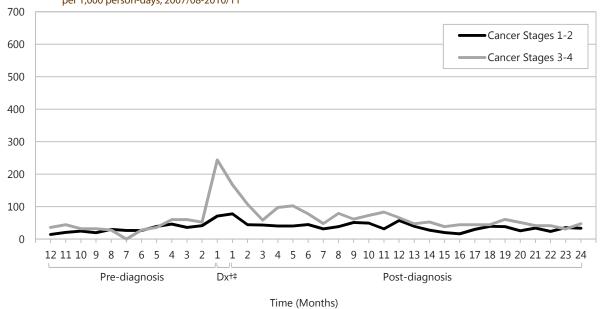


Figure 3.11: Crude Rates of Emergency Department Use for Prostate Cancer Cohort by Cancer Stage per 1,000 person-days, 2007/08-2010/11

 D_{x} indicates the peri-diagnosis period

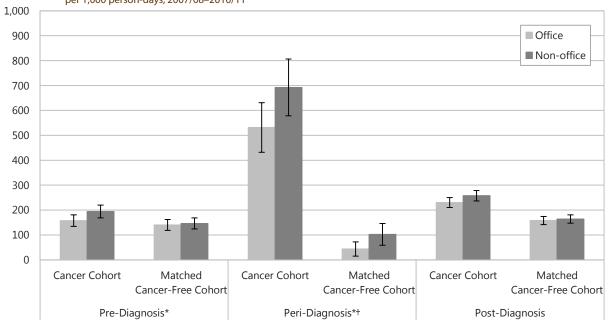
 \star indicates a statistically significant difference in adjusted rates between cancer stages in this period (α =0.05)

+ indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for cancer stages 1-2 (α =0.05)

* indicates a statistically significant difference from adjusted rates in the pre-diagnosis period for cancer stages 3-4 (α =0.05)

Note: values suppressed due to small numbers are shown as zeroes





Error bars indicate 95% confidence intervals

* indicates a statistically significant difference between rates in office and non-office hour time segments for the cancer cohort (α=0.05)

+ indicates a statistically significant difference between rates in office and non-office hours time segments for the matched cancer-free cohort (α=0.05)

Table 3.1 summarizes the differences in ED use across the three diagnosis periods, stratified by type of cancer and adjusted for confounding covariates, for the cancer cohorts relative to the matched cancer-free cohorts. These results show that there were no statistically significant differences between the cancer cohorts and the matched cancer-free cohorts in the pre-diagnosis period for any type of cancer, with the exception of lung cancer. All four cancer cohorts exhibited significantly higher rates of ED use relative to their matched cancer-free cohorts in the post-diagnosis period, all cancer cohorts except the prostate cancer cohort had significantly higher rates of ED use relative to the matched cancer cohorts.

Additional model results for these analyses are available in Appendix Tables 3.1 to 3.4.

Winnipeg residents, 2007/0		
Cancer Site	Time Period	Relative Rate (95% Confidence Interval)
	Pre-diagnosis	1.11 (0.82, 1.50)
Breast	Peri-diagnosis	1.74 (1.31, 2.32)
	Post-diagnosis	1.45 (1.26, 1.67)
	Pre-diagnosis	1.18 (0.92, 1.50)
Colorectal	Peri-diagnosis	2.44 (1.72, 3.45)
	Post-diagnosis	1.40 (1.11, 1.76)
	Pre-diagnosis	1.38 (1.18, 1.62)
Lung	Peri-diagnosis	4.51 (3.61, 5.63)
	Post-diagnosis	2.28 (1.94, 2.67)
	Pre-diagnosis	1.14 (0.93, 1.41)
Prostate	Peri-diagnosis	3.10 (2.14, 4.47)
	Post-diagnosis	1.20 (0.98, 1.46)

Table 3.1: Relative Rates of Emergency Department Use for Cancer Cohorts Versus Matched Cancer-Free Cohorts, Stratified by Cancer Site Winnipeg residents, 2007/08-2010/11

Model covariates include age, sex, income quintile, comorbidity, inpatient hospitalizations, majority of care, ambulatory physician visits, and prescription drug dispensations.

Bold values indicate a statistically significant difference from matched cancer-free cohort at α =0.05. Matched cancer-free cohort is the reference group.

Table 3.2 summarizes the difference in ED use rates between individuals with cancer stage 1-2 and stage 3-4 across the diagnosis periods (using stage 1-2 as the reference category), stratified by type of cancer and adjusted for confounding covariates (including cancer stage and treatment type). These results show that ED use in the cancer cohorts was generally higher for stage 3-4 when compared with stage 1-2. Relative rates in the peri-diagnosis period ranged from 1.35 (colorectal) to 2.44 (breast). In the post-diagnosis period, relative rates ranged from 0.91 (prostate) to 1.69 (colorectal).

Additional model results for these analyses are available in Appendix Tables 3.5 to 3.8.

Appendix Table 3.9 summarizes the differences in ED use across office hour and non-office hour time segments during the three diagnosis periods, stratified by type of cancer and adjusted for confounding covariates. These results show that there was no overall statistically significant difference between office and non-office hour segments for the cancer cohorts and matched cancer-free cohorts. ED use in non-office hour time segments for the cancer cohorts was significantly higher than ED use in office hour segments during the pre- and peri-diagnosis periods for prostate cancer, and during the post-diagnosis period for breast cancer and colorectal cancer.

Objective 2: Reasons for Emergency Department Use by the Cancer Cohort in the Pre-, Peri-, and Post-Diagnosis Periods

Figure 3.13 contains crude rates of the five most common ED complaints during the pre-diagnosis period across cancer sites. Corresponding rates for the matched cancer-free cohort are presented for comparison purposes. Asterisks indicate a statistically significant difference between the two groups. Rates are scaled to be comparable across Figure 3.13 to Figure 3.15. There were significant differences between the cancer cohort and matched cancer-free cohort for all sites except breast cancer. For colorectal cancer, skin and abdomen/gastrointestinal complaints were more common than for the cancer-free cohort. For lung cancer, respiratory and general/ non-specific complaints were more common. For prostate cancer, genitourinary complaints were more common. These findings highlight the importance of examining the specific reasons of ED visits by cancer site. The significant differences we detected when we examined specific reasons for ED visits may not be evident in broader comparisons of ED use.

Figure 3.14 shows crude rates of the five most common reasons for using the ED during the peri-diagnosis period across cancer sites. As indicated, dramatic differences between the cancer and cancer-free cohorts begin to emerge during this time period. The rate of respiratory complaints for the lung cancer cohort is almost 20 times higher compared to the cancer-free cohort; the rate of abdomen/gastrointestinal complaints for colorectal cancer patients is about 60 times higher. ED use for the cancer-free cohort matched to the prostate cancer cohort was so low that the numbers were suppressed. The duration of this time period (two months) might also contribute to the low number of ED visits, compared with the pre- and post- diagnosis periods. This emphasizes the dramatic increase in ED use for the colorectal and lung cancer cohorts from the pre-diagnosis period. Some of the differences in ED use between cancer and matched cancer-free cohorts might arise from known side effects of treatment, notably radiation therapy (i.e., skin irritation), chemotherapy (i.e., gastrointestinal irritation, nausea, vomiting, dehydration, rash, diarrhea), and surgery (i.e., pain, hematoma, fever/infection – categorized as general/non-specific complaints) (Barbera et al., 2010; Kreys, Kim, Delgado, & Koeller, 2014; Mayer, Travers, Wyss, Leak, & Waller, 2011).

Figure 3.15 shows crude rates of the five most common reasons for using the ED during the post-diagnosis period across cancer sites. While the dramatic differences seen in the peri-diagnosis period have diminished, we still see significantly higher ED use for the cancer cohorts compared to the matched cancer-free cohorts for a number of ED complaints. Breast cancer patients had significantly higher rates of complaints in the general/non-specific, chest/ cardiovascular, abdomen/gastrointestinal, and respiratory categories. Colorectal cancer patients had higher rates of abdomen/gastrointestinal, general/non-specific, and chest/cardiovascular complaints. Prostate cancer patients had significantly higher ED use for genitourinary and general/non-specific reasons.

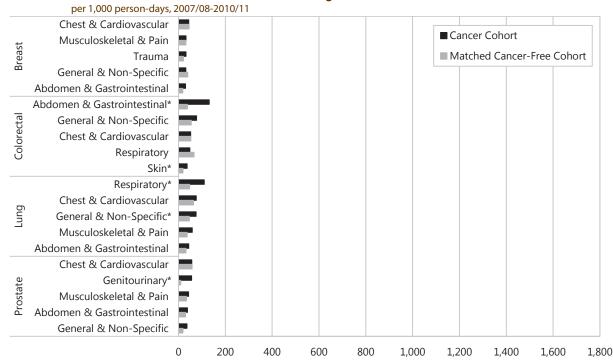
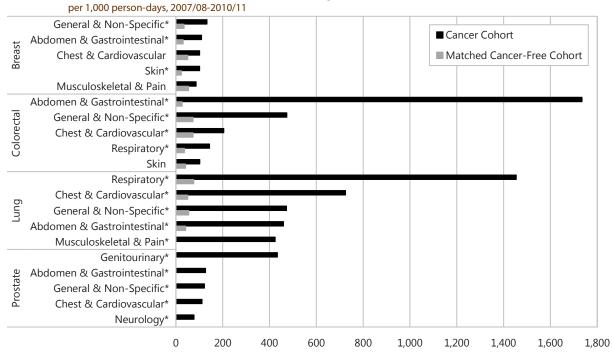


Figure 3.13: Crude Rates of Emergency Department Use by Top 5 Complaint Categories for Cancer Cohorts and Matched Cancer-Free Cohort in Pre-Diagnosis Period

* indicates a statistically significant difference in rates between the cancer and matched cancer-free cohorts at α =0.05

Figure 3.14: Crude Rates of Emergency Department Use by Top 5 Complaint Categories for Cancer Cohorts and Matched Cancer-Free Cohort in Peri-Diagnosis Period



 * indicates a statistically significant difference in rates between the cancer and matched cancer-free cohorts at α =0.05 Note: values suppressed due to small numbers are shown as zeroes

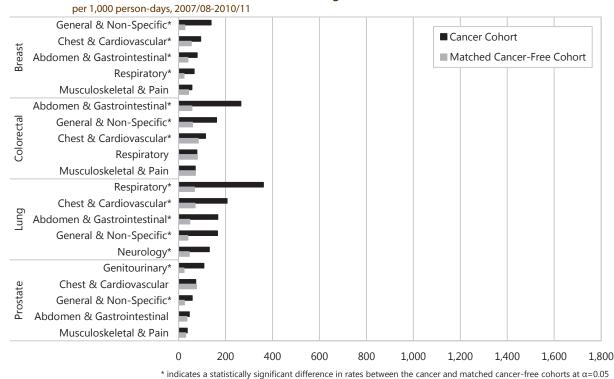


Figure 3.15: Crude Rates of Emergency Department Use by Top 5 Complaint Categories for Cancer Cohorts and Matched Cancer-Free Cohort in Post-Diagnosis Period

Objective 3: Emergency Department Use and Cancer Cohort Survival

The third objective focused on the independent association between ED use and mortality in the cancer cohort. Summary results are provided in the following section and Appendix 4.

As shown in Table 3.3, ED use for the breast cancer cohort was associated with mortality in the post-diagnosis period only (hazard ratio (HR) = 1.28, p < 0.0001), even after controlling for other healthcare use (e.g., hospitalization and physician visits, drug prescribing). A similar finding was observed for colorectal and lung cancer. However, prostate cancer showed a statistically significant association between mortality and ED use in the pre-diagnosis period (HR = 1.12, p < 0.02), but no association with ED use in the post-diagnosis period (HR = 1.02, p = 0.7018).

Table 3.3: Hazard Ratios for the Association Between ED Use in the Pre- and Post-Diagnosis Periods and Mortality, Stratified by Cancer Site Winnipeg residents, 2007/08-2011/12

Cancer Site	Time Period	Hazard Ratio (95% Confidence Interval)
Breast	Pre-diagnosis	0.98 (0.93, 1.04)
Dreast	Post-diagnosis	1.27 (1.18, 1.37)
Colorectal	Pre-diagnosis	1.04 (0.99, 1.10)
Colorectai	Post-diagnosis	1.11 (1.04, 1.18)
Lung	Pre-diagnosis	1.04 (1.00, 1.08)
Lung	Post-diagnosis	1.10 (1.06, 1.14)
Prostate	Pre-diagnosis	1.12 (1.02, 1.24)
FIOSTATE	Post-diagnosis	1.02 (0.91, 1.16)

Model covariates include age, sex, income quintile, cancer stage, comorbidity, inpatient hospitalizations, ambulatory physician visits, and drug prescription dispensations.

Pre-diagnosis period includes one year before diagnosis.

Post-diagnosis period is time-varying, every six months.

Bold values indicate a statistically significant effect at α =0.05.

Overall, these results suggest that ED use after cancer diagnosis is strongly associated with death. These results are not consistent with Elliss-Brookes et al. (2012), who found that patients for whom the pathway to diagnosis involved the ED had a lower one-year relative survival compared to patients with other pathways to cancer diagnosis (e.g., screening, visits to a general practitioner). To determine if there were instances where prior ED use could be related to a significantly elevated risk of death, we included only ED use in the year prior to diagnosis in the model; with each additional ED visit, cancer patients had a 5% (breast) to 41% (prostate) significantly increased risk of death (data not shown). However, when accounting for healthcare use before and after cancer diagnosis, overall level of sickness, cancer stage, and socio-demographic characteristics, we found that the risk of death associated with ED use prior to diagnosis was not significant (data not shown). Summary cancer stage at diagnosis had the strongest association with mortality (Appendix 4). Stage 4 cancer patients had a seven-fold (lung) to 27-fold (breast) increase in the risk of death compared to stage 1 cancer patients. Also, the rate of ED visits in the year prior to cancer diagnosis was consistently higher for patients with advanced cancer stage. This suggests not only that ED use prior to diagnosis is related to cancer stage at diagnosis but also that the ED cancer pathway to diagnosis alone does not account for increased mortality. Higher risk of death is significantly related to a host of factors including cancer stage at diagnosis, socio-demographic variables, and presence of comorbid conditions.

Conclusions

Linkage of Manitoba Cancer Registry data to administrative data from the Research Data Repository housed at MCHP was used to examine and report on ED use for a variety of cancer cohorts. The results suggest that EDs are an important part of the care pathway for cancer patients. Investigating why they are used might lead to better diagnostic or treatment options that could benefit cancer patients.

Several questions were not addressed in this demonstration project. For example, we did not investigate the relationship between continuity of care (or access to care) and subsequent presentation at an ED with a diagnosis of cancer. One of the implications of being diagnosed in the ED is the possibility that there is insufficient or inadequate care available in the community. Investigating access to care prior to diagnosis may lead to the identification of gaps that are preventable. Another area that was beyond the scope of this demonstration project was the question of common characteristics of patients diagnosed with cancer in the ED. Are they older or younger, sicker or healthier, richer or poorer? These are important questions that could be examined in future studies.

CHAPTER 4: DEMONSTRATION PROJECT 2: MEASURING COMORBIDITY IN CANCER PATIENTS

Introduction

Comorbidity is defined as the total burden of illness across multiple conditions that co-occur with a patient's principal diagnosis (Valderas, Starfield, Sibbald, Salisbury, & Roland, 2009). The presence of comorbid conditions in a patient is typically associated with poor health outcomes, greater complexity of patient treatment and management, and increased health care use and costs.

Cancer patients often have comorbidities as pre–existing conditions or as a consequence of their cancer (Klabunde, Legler, Warren, Baldwin, & Schrag, 2007). For example, lung cancer patients are more likely to have tobacco–related chronic conditions such as hypertension and heart disease, and patients who are treated with certain chemotherapies may develop cardiovascular conditions. As well, life expectancy is increasing for some groups of cancer patients because of improved treatment options; older patients with cancer are more likely to have comorbid conditions as a consequence of the aging process.

Cancer registries do not routinely collect information about comorbid conditions, so these conditions must be ascertained from other data source(s) that can be linked to cancer registries. Administrative health data are an efficient source of comorbidity information because of their low cost compared to primary data collection, comprehensive coverage of the population, linkage capabilities, and relative ease of data processing to extract comorbidity information. Klabunde et al. (2007) compared two types of administrative health data—hospital abstracts and physician claims—for measuring comorbid conditions in patients with diagnosed melanoma or breast, colorectal, or bladder cancers. These two data sources varied in their sensitivity to detect comorbid conditions, so the authors recommended that both sources be used in a complementary manner to detect comorbid conditions. Some comorbidity measures, such as the Charlson and Elixhauser indices, were initially developed using hospital abstracts, but methods to use diagnosis information from other data sources (e.g., outpatient physician billing claims) have been developed (Lix, Quail, Fadahunsi, & Teare, 2013). Prescription drug records, which contain information on medication dispensations, are another administrative data source that have been used to measure comorbidity.

There is no agreement on the optimal measure of comorbidity to apply to any patient population; both general–purpose and disease–specific measures have been developed and each has strengths and limitations. Predictive performance, comprehensiveness, ease of application to one's data, generalizability to different patient populations, and interpretability to clinical and non–clinical audiences might all be considered when selecting a comorbidity measure. For cancer patients, a number of site–specific measures have been developed. Their primary limitation is the ability to compare comorbidity across different cancer sites or for diagnosed patients and cancer–free individuals.

Comorbidity measures have several uses in epidemiologic and health services research studies. They play a central role in observational studies where causal inferences about exposures and outcomes are of interest. Descriptive studies of the comorbid characteristics of different patient populations have been used to define disease burden and test for changes in burden over time. In clinical trials, comorbidity scores may be used to randomly allocate patients to treatment groups, to ensure balance in the groups on the level of comorbidity.

In outcomes research, comorbidity measures often do have not equivalent predictive validity (Baser, Palmer, & Stephenson, 2008). Predictive performance will typically vary with the population under investigation and outcome of interest. For example, in a large observational study of head and neck cancer patients, Boje et al. (2014) found that 36% of patients had at least one comorbid condition, with many patients having multiple conditions. However, only six conditions were useful for predicting the five–year survival probability: congestive heart failure,

cerebrovascular disease, chronic pulmonary disease, peptic ulcer disease, liver disease, and diabetes. The authors developed a new comorbidity index specifically designed for use amongst head and neck cancer patients; they found that it had better predictive performance than existing measures, including the Charlson index.

Purpose and Objectives

Given this background, the overall purpose of this demonstration project was to evaluate the performance of comorbidity measures for predicting health and healthcare use outcomes in populations with diagnosed cancers. The specific objectives were to investigate the predictive performance of diagnosis–based and prescription drug–based comorbidity measures for: (a) all–cause and in–hospital mortality, (b) inpatient and outpatient healthcare use (e.g., ambulatory care, prescription drug use), and (c) selected acute and chronic health conditions. An additional objective was to compare the comorbidity characteristics of cancer patients with cancer–free individuals from the general population. This information on comorbidity can be used to produce recommendations on the optimal method(s) to measure comorbidity in individuals with a cancer diagnosis.

Methods

The study data sources included the Manitoba Cancer Registry, Manitoba Health Insurance Registry, Hospital Abstract data, Medical Services (physician billing claims), Drug Program Information Network Data (prescription drug records), Vital Statistics Mortality Registry (mortality records), and Statistics Canada Census data (area-level income) from the Repository housed at MCHP. Information about the cancer registry data⁶ and methods used in the analysis are provided in Appendix 1.

Manitoba Cancer Registry data were used to identify the study cohort, cancer site, date of cancer diagnosis, stage (for 2004 onward), and treatment methods. The population registry was used to ascertain health insurance coverage, socio–demographic variables, and date of death (based on health insurance coverage cancellation code). Hospital discharge abstracts, physician billing claims, and prescription drug records were used to derive the comorbidity measures. Patient outcomes, including healthcare use, acute health conditions, and chronic health conditions were defined using hospital discharge abstracts and physician billing claims.

A retrospective cohort design was adopted. All individuals with a confirmed cancer diagnosis in the Manitoba Cancer Registry between April 1, 1997 and December 31, 2011 were eligible to be included in the study cohort. However, only individuals with selected cancer sites were included; the selection was based on both the research team interests and the likelihood of having adequate numbers of individuals to ensure that predictive validity could be precisely estimated.

The cohort was stratified by cancer site: bladder, breast, colorectal, chronic lymphocytic leukemia (CLL), lung and prostate cancer. Only adults (i.e., 18+ years at the date of cancer diagnosis) were retained in the cohort. If individuals had more than one type of cancer diagnosed in the observation period, then only the first cancer diagnosis was used to identify the site. Individuals who did not have health insurance coverage for the entire duration of the comorbidity observation window prior to cancer diagnosis date were excluded. Other exclusions based on health insurance coverage were specific to each of the outcomes under investigation.

The cancer cohort was compared to a matched general population cohort that did not have any cancer diagnoses (i.e., the matched cancer–free cohort) on the comorbidity measures. The matching variables were age group (5– year groups beginning with 18–24 years), sex, health region (Winnipeg, Prairie Mountain Health, Interlake–Eastern, Northern, Southern Health/Santé Sud), income quintile (urban and rural quintiles were combined), and fiscal year of diagnosis.

⁶ Descriptions of the Manitoba cancer registry and all other data used in this report can be found on the MCHP website http:// umanitoba.ca/faculties/medicine/units/community_health_sciences/ departmental_units/mchp/resources/repository/datalist. html

Multiple comorbidity measures were investigated. However, we focused on general–purpose measures in this study, because they enable comparisons across different cancer sites, as well as between cancer patients and the matched cancer–free cohort. The selected measures included:

- Number of diagnoses: Number of different diagnoses as defined using the International Classification of Diseases (ICD) for hospital and physician data (Schneeweiss & Maclure, 2000). The number of diagnoses was based on three–digit ICD–9–CM and three–digit ICD–10–CA codes.
- **Number of prescription drugs**: Number of different prescription drugs as defined using Anatomic Therapeutic Chemical (ATC) classification codes (Perkins et al., 2004). The number of different drugs was defined using the fourth level of ATC codes.
- **Charlson index**: This index is based on a list of 19 conditions identified from diagnoses in hospital and physician data. Each condition is assigned a weight from 1 to 6. The index score is the sum of the weights for all identified conditions (Charlson et al., 1987). An index score of 0 indicates no comorbid conditions, while higher scores indicate a greater level of comorbidity.
- Elixhauser index: This index is based on 31 individual conditions identified from diagnoses in hospital and physician data. Binary indicator variables are used to ascertain the presence/absence of each condition in the data source(s) (Elixhauser, Steiner, Harris, & Coffey, 1998; van Walraven, Austin, Jennings, Quan, & Forster, 2009).
- **Chronic Disease Score**: This measure is based on prescription drug use data for selected chronic conditions (categorized by ATC classification codes). A single summary score is produced, which has a lower bound of zero but no upper bound (Clark, Von Korff, Saunders, Baluch, & Simon, 1995; Von Korff, Wagner, & Saunders, 1992).
- Johns–Hopkins Adjusted Clinical Group[®] (ACG[®])⁷ indices: Each patient is allotted to a single ACG group; patients in each group have the same type and degree of comorbidity. The case–mix system identifies common combinations of morbidities that determine an individual's need for health services (Reid, MacWilliam, Roos, Bogdanovic, & Clack, 1999). This study focused on Resource Utilization Bands (RUBs), of which there are six, and Aggregated Diagnostic Groups (ADGs[®]), of which there are 32.

Cancer diagnoses and cancer–specific prescription drugs were retained in these comorbidity measures, allowing for comparisons of the comorbidity measures between individuals in the cancer cohort and the matched cancer–free cohort. Comorbidity measurement was based on the one–year period prior to cancer diagnosis. In a sensitivity analysis, we used a comorbidity measurement period that extended from two to 14 months prior to cancer diagnosis, and assessed its impact on predictive performance (data not shown).

The predictive performance of the comorbidity measures with respect to each of the following outcomes was investigated:

- Mortality, including all-cause and in-hospital mortality in the one-year period following cancer diagnosis;
- Healthcare use, including inpatient hospitalization (0 versus 1+), rate of ambulatory physician visits, and rate of prescription drug dispensations in the one-year period following cancer diagnosis;
- Presence of selected incident acute and chronic conditions in the one-year period following cancer diagnosis
 including acute myocardial infarction (AMI), congestive heart failure (CHF), diabetes (note that the definition
 is based on the two-year period following cancer diagnosis), hypertension (note that the definition is based
 on the two-year period following cancer diagnosis), and osteoporotic-related fracture (hip, wrist, vertebral,
 humerus).

Measurement of these outcomes was based on validated case definitions previously applied to Manitoba's administrative health data (Lix et al., 2012b; Muhajarine, Mustard, Roos, Young, & Gelskey, 1997; Nova Scotia-Saskatchewan Cardiovascular Disease Epidemiology Group, 1989; Young, Roos, & Hammerstrand, 1991). For prescription drug outcome measures, the comorbidity measure based on the number of different prescription drugs was not investigated.

7 The Johns–Hopkins Adjusted Clinical Group® (ACG®) indices were created using The Johns Hopkins Adjusted Clinical Group® (ACG®) Case–Mix System version 10.

The data were descriptively analyzed using frequencies, percentages, means, and standard deviations. Cumulative mean numbers of new prescription drugs and new diagnoses were calculated over the period from 23 months before cancer diagnosis to 12 months after cancer diagnosis.

Multivariable logistic regression models for binary outcomes and negative binomial regression models for healthcare use rates of ambulatory physician visits and prescription drug dispensations were applied to the data. For the negative binomial regression models, the offset was the number of person–days of observation in the one–year period following cancer diagnosis.

Two models were compared for each comorbidity measure and outcome measure combination for each of the cancer cohorts:

- Base model: included the covariates of age, sex, health region, income quintile, and treatment.
- Full model: included all of the covariates in the base model in addition to one or more variables for the comorbidity measure or score under investigation (i.e., two or more dummy variables were defined where a categorical comorbidity measure was included in the model).

All analyses were stratified by cancer site. Age was included in the model as a categorical variable. Health region was a categorical variable with the following categories: Winnipeg, Prairie Mountain Health, Interlake–Eastern, Northern, Southern Health/Santé Sud. Rural and urban income quintiles were combined, so that the income quintile variable had six levels: Q1 (lowest), Q2, Q3, Q4, Q5 (highest), and missing quintile (i.e., Income Unknown). Treatments included surgery, radiation, chemotherapy, and hormone therapy. Note that not all treatments were represented in the data for all cancer sites and the types of treatment were not mutually exclusive.

For the logistic regression model, discriminative/predictive performance of comorbidity measures was assessed using the area under the receiver operating characteristic (ROC) curve, which is equivalent to the c-statistic. For the negative binomial model, predictive performance was assessed using a measure of explained variation, the pseudo–R2 statistic. The c-statistic ranges in value from zero to one, with a value of one representing perfect prediction and a value of 0.5 representing chance prediction. A value between 0.7 and 0.8 is considered to demonstrate acceptable predictive performance, while a value greater than 0.8 demonstrates excellent discriminative performance. The pseudo–R2 statistic can range in value from zero to one, with larger values indicating an improvement in explained variation; there are no specific cut–points proposed to ascertain high predictive performance. The difference in discriminative performance or explained variance between the base and full models was tested (Harrell, Lee, & Mark, 1996). The percentage change in the c–statistic or pseudo–R2 statistic between the base and full models was also calculated.

Prediction error of both the base and full models was assessed using the Brier score for the logistic regression model (Redelmeier, Bloch, & Hickam, 1991) and the root mean square error (RMSE) for the negative binomial model (Harrell, 2001). The Brier score is a measure of calibration that can range in value from zero to one; the lower the Brier score is for a set of predictions, the better the predictions are calibrated. The RMSE is a measure of the average prediction error and ranges from zero to infinity, with smaller values indicating less error. The difference in prediction error for the base and full models was tested.

For logistic regression models, reclassification statistics were also employed to measure and compare each model's predictive performance (Cook & Paynter, 2011; Pencina, D'Agostino, D'Agostino, & Vasan, 2008; Steyerberg et al., 2010). These included the integrated discrimination improvement (IDI) and the net reclassification improvement (NRI) indices. The IDI and NRI indices measure the "risk refinement" or the number of cancer patients that are reclassified as true events without sacrificing average specificity. These measures provide another way to assess a model's improvement in predictive performance; the area under the ROC curve may not be sensitive to change in discriminative performance. Higher positive values for the NRI and IDI indicate better predictive performance. Changes in the IDI and NRI statistics were tested. In addition the percent of events and non–events that were

correctly reclassified by inclusion of a comorbidity measure into the base model was calculated, to provide information about the relative impact of the comorbidity measure on correct classification of cancer patients with the outcome of interest. All results for the NRI and IDI are reported in Appendix 6.

Results

Descriptive Statistics for Cancer Cohort

Table 4.1 contains descriptive information on the characteristics of the cancer cohort (N = 34,569), as well as of the cancer site–specific cohorts. The largest numbers of cancer patients in the observation period from 1997/98 to 2011/12 had lung (25.1%) and breast (24.6%) cancers. Mean age was highest for bladder cancer patients and lowest for breast cancer patients. Frequencies of cancer patients by sex, region of residence, income quintile, and treatment methods were consistent with previously reported trends.

			Chronic			
	Bladder	Breast	Lymphocytic	Colorectal	Lung	Prostate
Characteristics			Leukemia		5	
	(n=1,230)	(n=8,485)	(n=839)	(n=7,903)	(n=8,689)	(n=7,423)
Age (Years)						
Mean (Standard Deviation)	71.3 (12.7)	61.7 (14.3)	68.4 (12.4)	68.6 (13.3)	69.1 (11.3)	68.6 (9.9)
Sex (%)						
Male	72.1	0.6	55.0	53.1	51.5	100.0
Female	27.9	99.4	45.1	46.9	48.5	0.0
Region of Residence (%)						
Southern Health/Santé Sud	11.8	11.7	10.9	11.9	10.4	11.6
Winnipeg	58.6	60.7	59.0	56.6	59.3	55.7
Prairie Mountain Health	16.6	14.4	16.5	17.4	16.2	17.0
Interlake-Eastern	10.6	10.5	11.8	10.4	10.4	12.8
Northern	2.4	2.8	1.9	3.7	3.8	2.9
Income Quintiles (%)						
Q1 (Lowest)	19.6	18.6	19.2	21.2	24.9	17.3
Q2	23.5	18.2	18.2	20.4	22.9	19.3
Q3	18.8	18.9	19.3	20.1	20.4	19.9
Q4	16.4	18.0	16.5	16.3	15.6	18.2
Q5 (Highest)	13.2	18.7	18.2	15.0	13.0	18.6
Year of Cancer Diagnosis (%)						
1997/98 - 2003/04	49.5	42.8	44.0	43.7	45.7	45.2
2004/05 - 2011/12	50.5	57.2	56.0	56.3	54.3	54.8
Cancer Treatment* (%)						
Chemotherapy	13.2	43.7	25.5	37.7	25.5	2.5
Hormone Therapy	n/a	54.5	n/a	0.1	0.1	33.3
Radiation Therapy	23.0	62.8	2.5	19.5	45.9	36.0
Surgical Intervention	89.5	92.5	1.4	82.8	22.5	50.9

Table 4.1: Demographic, Diagnosis, and Treatment Characteristics of Cancer Cohort By site, 1997/98-2011/12

Some patients received more than one treatment, therefore column percentages do not sum to 100
 n/a Indicates not applicable

Comparisons between Cancer Cohort and Matched Cancer-Free Cohort

A total of 125 cancer patients could not be matched to a cancer–free cohort member and are therefore excluded from the analysis. The cancer cohort and matched cancer–free cohort are described on the continuous comorbidity measures in Table 4.2; included are the number of ADGs[®], Chronic Disease Score, number of different diagnoses, number of different prescription drugs, RUBs, and the Charlson index.

As expected, individuals in the cancer cohort had a higher level of comorbidity than individuals in the cancer–free cohort on most measures and across all cancer sites. Differences between the two groups were largest for lung and prostate cancers.

Table 4.2: Descriptive Statistics (Mean and Standard Deviation) of Comorbidity Measures for Cancer Cohort and Matched Cancer-Free Cohort

By cancer site, 1997/98–2011/13

by cancer site, 1997/98-2011/15	· · ·	Matched	
	Cancer		Standardized
Comorbidity Measures	Cohort	Cancer-Free	Difference
	conort	Cohort	Difference
Bladder	1	1	1
No. of Diagnoses	5.79 (4.59)	4.38 (4.37)	0.31
No. of Drugs	7.43 (4.76)	4.77 (4.57)	0.55
No. of Aggregated Diagnosis Groups™	5.72 (2.80)	3.65 (2.92)	0.68
Resource Utilization Bands	3.47 (0.82)	2.65 (1.30)	0.70
Chronic Disease Score	2.51 (2.23)	2.21 (2.21)	0.14
Charlson Index	1.66 (1.66)	0.67 (1.20)	0.64
Breast			0.01
No. of Diagnoses	4.37 (3.93)	4.31 (4.17)	0.01
No. of Drugs	5.55 (3.88)	4.61 (4.18)	0.23
No. of Aggregated Diagnosis Groups™	4.47 (2.57)	3.62 (2.80)	0.31
Resource Utilization Bands	3.06 (0.78)	2.57 (1.16)	0.48
Chronic Disease Score	2.04 (1.99)	2.02 (2.09)	0.01
Charlson Index	0.98 (1.36)	0.45 (0.87)	0.45
Chronic Lymphocytic Leukemia	· · · · · · · · · ·	· · · · · · · · · · · ·	1
No. of Diagnoses	4.86 (4.03)	4.35 (4.13)	0.13
No. of Drugs	5.87 (3.95)	4.66 (4.27)	0.29
No. of Aggregated Diagnosis Groups™	4.61 (2.60)	3.65 (2.88)	0.35
Resource Utilization Bands	3.16 (0.88)	2.64 (1.21)	0.48
Chronic Disease Score	2.34 (2.04)	2.14 (2.09)	0.10
Charlson Index	1.26 (1.32)	0.63 (1.22)	0.48
Colorectal		1	- · · ·
No. of Diagnoses	4.97 (4.19)	4.44 (4.15)	0.13
No. of Drugs	7.24 (4.53)	4.64 (4.28)	0.57
No. of Aggregated Diagnosis Groups™	5.44 (2.72)	3.60 (2.80)	0.63
Resource Utilization Bands	3.37 (0.84)	2.63 (1.21)	0.67
Chronic Disease Score	2.39 (2.10)	2.20 (2.09)	0.09
Charlson Index	1.55 (1.80)	0.60 (1.05)	0.61
Lung	1	1	
No. of Diagnoses	6.40 (4.67)	4.58 (4.21)	0.40
No. of Drugs	7.91 (4.66)	4.72 (4.19)	0.68
No. of Aggregated Diagnosis Groups™	6.02 (2.78)	3.68 (2.78)	0.78
Resource Utilization Bands	3.70 (0.95)	2.64 (1.18)	0.89
Chronic Disease Score	3.12 (2.30)	2.27 (2.12)	0.38
Charlson Index	2.43 (2.10)	0.58 (1.01)	0.98
Prostate	1	1	1
No. of Diagnoses	4.91 (3.67)	4.16 (4.08)	0.19
No. of Drugs	5.97 (3.81)	4.39 (4.21)	0.39
No. of Aggregated Diagnosis Groups™	4.62 (2.46)	3.42 (2.75)	0.45
Resource Utilization Bands	3.24 (0.74)	2.59 (1.27)	0.59
Chronic Disease Score	2.14 (1.90)	2.10 (2.06)	0.02
Charlson Index	1.23 (1.44)	0.63 (1.09)	0.46

Bold values indicate a significant difference between cancer cohort and matched cancer-free cohort at α =0.05

Table 4.3 contains the percentages of individuals in the cancer cohort and matched cancer–free cohort that had each of the comorbid conditions comprising the Charlson index, by cancer site. For both the cancer cohort and the matched cancer–free cohort, the most common comorbid conditions were, in general, diabetes without complications, chronic pulmonary disease, and congestive heart failure. While many comorbid conditions were more common in the cancer cohort than in the matched cancer–free cohort, this was not always the case. For example, congestive heart failure, peripheral vascular disease, cerebrovascular disease, and dementia were less common amongst breast cancer cases than matched controls. The corresponding percentages for the cancer cohort and the matched cancer–free cohort on the Elixhauser index are shown in Table 4.4. A similar picture of the common comorbid conditions emerged from the application of this index to the administrative data.

Table 4.3: Percent of Patients with Charlson Index Diagnoses in the Cancer Cohort and Matched Cancer-
Free Cohort

	Bla	dder	Br	east	Chronic Lymphocytic Leukemia	
Charlson Index Diagnoses	Cancer Cohort	Matched Cancer-Free Cohort	Cancer Cohort	Matched Cancer-Free Cohort	Cancer Cohort	Matched Cancer-Free Cohort
Cancer	41.2	2.3	28.3	1.4	37.2	3.0
Chronic Pulmonary Disease	15.8	11.9	10.6	11.1	13.0	11.3
Diabetes without Complications	14.9	13.4	10.2	9.7	11.8	12.2
Congestive Heart Failure	8.2	6.9	2.8	3.8	5.7	5.1
Cerebrovascular Disease	5.1	4.2	2.2	3.2	2.9	5.5
Dementia	5.1	6.9	2.3	3.9	2.4	5.8
Renal Disease	4.9	2.5	0.8	1.1	0.8	1.9
Peripheral Vascular Disease	4.8	3.6	1.2	1.6	2.4	2.0
Myocardial Infarction	3.7	1.6	0.7	0.7	1.7	1.4
Diabetes with	2.0	1.0	0.5	0.6	1 0	1.2
Complications	2.0	1.6	0.5	0.6	1.3	1.2
Paraplegia and Hemiplegia	1.6	S	0.2	0.3	0.7	S
Connective Tissue Disease- Rheumatic Disease	1.5	1.0	1.8	2.3	1.1	1.7
Peptic Ulcer Disease	1.5	1.4	0.9	1.0	1.1	1.3
Mild Liver Disease	0.7	0.6	0.8	0.9	1.9	1.0
Metastatic Carcinoma	0.7	S	0.8	S	S	S
Moderate or Severe Liver Disease	S	S	0.1	0.1	S	S
HIV/AIDS	S	S	0.0	0.0	0.0	0.0

By cancer site, 1997/98–2011/12

Bold values indicate a significant difference between cancer cohort and matched cancer-free cohort at α =0.05

Table 4.3: Continued

	Colo	rectal	Lung		Prostate	
Charlson Index Diagnoses	Cancer Cohort	Matched Cancer-Free Cohort	Cancer Cohort	Matched Cancer-Free Cohort	Cancer Cohort	Matched Cancer-Free Cohort
Cancer	37.6	1.8	57.3	1.8	34.3	2.1
Chronic Pulmonary Disease	12.6	12.3	35.1	12.4	11.5	11.7
Diabetes without Complications	16.2	13.3	13.1	13.5	14.0	15.2
Congestive Heart Failure	7.2	5.7	9.1	5.4	4.9	6.0
Cerebrovascular Disease	3.9	4.8	6.0	4.0	3.6	4.4
Dementia	2.9	5.4	3.2	3.7	1.8	4.5
Renal Disease	2.1	1.8	2.1	1.7	2.1	2.1
Peripheral Vascular Disease	3.1	2.5	6.0	2.5	2.4	3.1
Myocardial Infarction	2.6	1.5	2.9	1.5	1.6	1.9
Diabetes with Complications	1.7	0.9	1.5	1.0	1.0	1.1
Paraplegia and Hemiplegia	0.6	0.7	0.6	0.6	0.5	0.7
Connective Tissue Disease- Rheumatic Disease	1.6	1.6	3.1	1.9	1.1	1.1
Peptic Ulcer Disease	2.8	1.0	1.9	1.3	1.1	1.2
Mild Liver Disease	1.0	0.7	1.3	0.7	0.6	0.9
Metastatic Carcinoma	2.6	S	6.2	0.1	0.8	S
Moderate or Severe Liver Disease	0.4	0.2	0.2	0.1	0.1	0.3
HIV/AIDS	S	S	S	S	0.0	S

Bold values indicate a significant difference between cancer cohort and matched cancer-free cohort at α =0.05

Table 4.4: Percent of Patients with Elixhauser Index Diagnoses in the Cancer Cohort and Matched Cancer-Free Cohort

	Bla	dder	Bre	east	-	mphocytic
					Leuk	emia
Elixhauser Index		Matched		Matched		Matched
Diagnoses	Cancer	Cancer-	Cancer	Cancer-	Cancer	Cancer-
	Cohort	Free	Cohort	Free	Cohort	Free
		Cohort		Cohort		Cohort
Solid Tumor without Metastasis	40.7	2.0	27.4	1.0	2.1	2.3
Hypertension without Complications	34.8	28.7	29.8	26.4	35.2	32.2
Chronic Pulmonary Disease	15.8	11.9	10.6	11.1	13.0	11.3
Diabetes without Complications	14.8	13.4	10.2	9.7	11.8	12.2
Depression	12.5	11.6	18.2	17.5	14.2	13.2
Cardiac Arrhythmia	10.0	6.9	3.8	3.5	7.6	5.7
Rheumatoid Arthritis/Collagen	9.1	8.2	10.8	10.7	9.7	10.5
Congestive Heart Failure	8.2	6.9	2.8	3.8	5.7	5.1
Peripheral Vascular Disorders	4.8	3.6	1.2	1.6	2.4	2.0
Renal Failure	4.5	2.5	0.8	1.0	0.8	1.8
Hypothyroidism	4.3	3.3	4.6	5.5	3.6	4.4
Deficiency Anemia	3.7	2.4	2.1	2.1	3.6	1.6
Fluid and Electrolyte Disorders	2.9	2.1	1.1	1.3	1.2	2.0
Other Neurological Disorders	2.8	4.7	2.3	3.6	3.1	5.0
Psychoses	2.3	4.1	1.6	2.6	1.6	3.1
Diabetes with Complications	2.0	2.0	0.6	0.6	1.4	1.4
Valvular Disease	1.8	1.4	0.6	0.7	1.9	1.4
Coagulopathy	1.7	0.9	0.7	0.6	1.9	1.3
Paralysis	1.6	S	0.2	0.3	0.7	S
Hypertension with Complications	1.3	0.7	0.4	0.3	S	1.1
Peptic Ulcer Disease Excluding Bleeding	1.3	1.4	0.9	0.9	1.0	1.3
Obesity	1.2	1.3	1.5	1.6	1.7	1.0
Liver Disease	0.9	0.7	0.8	0.9	2.0	1.0
Alcohol Abuse	0.8	S	0.3	0.4	0.7	0.7
Pulmonary Circulation Disorders	0.7	S	0.2	0.3	S	S
Metastatic Cancer	0.7	S	0.8	S	S	S
HIV/AIDS	S	S	0.0	0.0	0.0	0.0
Lymphoma	S	S	0.2	0.1	6.0	0.0
Weight Loss	S	0.5	0.1	0.2	S	0.0
Blood Loss Anemia	S	S	S	0.1	S	S
Drug Abuse	S	S	0.7	0.9	S	S

By cancer site, 1997/98–2011/12

Bold values indicate a significant difference between cancer cohort and matched cancer-free cohort at α =0.05

	Colo	rectal	Lu	ing	Pro	state
Elixhauser Index Diagnoses	Cancer Cohort	Matched Cancer- Free Cohort	Cancer Cohort	Matched Cancer- Free Cohort	Cancer Cohort	Matched Cancer- Free Cohort
Solid Tumor without Metastasis	37.1	1.4	56.4	1.4	33.8	1.7
Hypertension without Complications	34.8	30.6	32.7	32.8	35.7	29.5
Chronic Pulmonary Disease	12.6	12.3	35.1	12.4	11.5	11.7
Diabetes without complications	16.2	13.3	13.0	13.4	14.0	15.2
Depression	13.6	12.7	17.0	12.8	12.3	10.3
Cardiac Arrhythmia	7.7	5.9	7.4	6.2	6.7	6.7
Rheumatoid Arthritis/Collagen	9.3	9.5	12.4	9.8	9.2	8.2
Congestive Heart Failure	7.2	5.7	9.1	5.4	4.9	6.0
Peripheral Vascular Disorders	3.1	2.5	6.0	2.5	2.4	3.1
Renal Failure	1.9	1.7	2.0	1.7	2.0	2.0
Hypothyroidism	3.8	3.7	3.7	3.9	2.0	2.0
Deficiency Anemia	11.7	2.3	2.8	2.2	1.9	1.3
Fluid and Electrolyte Disorders	2.4	1.7	3.6	1.5	1.2	1.3
Other Neurological Disorders	3.1	4.0	3.7	3.8	2.5	3.7
Psychoses	1.9	2.9	2.6	2.3	1.0	2.3
Diabetes with Complications	2.0	1.1	1.6	1.2	1.1	1.2
Valvular Disease	1.6	1.0	1.3	1.6	1.1	1.1
Coagulopathy	1.4	0.9	1.2	0.8	0.9	1.0
Paralysis	0.6	0.7	0.6	0.6	0.5	0.7
Hypertension with Complications	0.7	0.4	0.7	0.6	0.5	0.5
Peptic Ulcer Disease Excluding Bleeding	2.6	1.0	1.7	1.2	1.1	1.1
Obesity	1.4	0.9	0.9	1.4	1.2	1.2
Liver Disease	1.2	0.8	1.4	0.8	0.7	1.1
Alcohol Abuse	0.8	0.8	1.4	0.9	0.9	1.3
Pulmonary Circulation Disorders	0.4	0.5	1.3	0.3	0.3	0.5
Metastatic Cancer	2.6	s	6.2	0.1	0.8	S
HIV/AIDS	S	S	S	s	0.0	S
Lymphoma	0.4	0.2	1.1	0.1	0.2	0.1
Weight Loss	0.9	0.2	0.5	0.1	0.1	0.3
Blood Loss Anemia	1.0	0.1	0.2	0.1	0.1	0.1
Drug Abuse	0.6	0.7	2.1	0.5	0.5	0.7

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Bold values indicate a significant difference between cancer cohort and matched cancer-free cohort at α =0.05

In Table 4.5, the percentage of the cancer cohort and matched cancer–free cohort in each of the RUB categories are shown by cancer site. A substantially higher percentage of the cancer cohort was in the "high morbidity" and "very high morbidity" categories when compared to the matched cancer–free cohort. The highest percentage of cancer patients in the very high morbidity category was for lung (23.0%) and bladder (13.9%), and the lowest was for breast (4.9%) and CLL (6.7%).

The cumulative mean number of new diagnoses in hospital discharge abstracts and physician billing claims and of new prescription drugs was measured over the period from 23 months prior to a cancer diagnosis to 12 months post–cancer diagnosis; the results are shown in Figures 4.1 and 4.2, respectively. All cancer sites demonstrated an increase in both the number of diagnoses and prescription drugs over this observation period. The rate of increase in the pre–diagnosis period was similar for all cancer sites. However, in the post–diagnosis period there was a larger rate of increase in the mean number of new diagnoses amongst lung, bladder, and colorectal cancer patients; for new prescription drug dispensations, the rate of increase in the mean number in the post–diagnosis period was much higher for lung cancer patients than it was for other cancer patients. See Appendix 5 for figures that show the cumulative mean number of new diagnoses and new prescription drug dispensations that include cancer–related diagnoses and drugs.

Table 4.5: Percent of Patients with Resource Utilization Bands in the Cancer Cohort and Matched Cancer-Free Cohort By cancer site, 1997/98-2011/12

					Chr	Chronic						
Resource	Bla	Bladder	Bre	Breast	Lympl Leuk	Lymphocytic Leukemia	Coloi	Colorectal	Γn	Lung	Pro	Prostate
Utilization Bands		Matched		Matched		Matched		Matched		Matched		Matched
(RUBs)	Cancer	Cancer-	Cancer	Cancer-	Cancer	Cancer-	Cancer	Cancer-	Cancer	Cancer-	Cancer	Cancer-
	Cohort	Free	Cohort	Free	Cohort	Free	Cohort	Free	Cohort	Free	Cohort	Free
		Cohort		Cohort		Cohort		Cohort		Cohort		Cohort
Non-user	s	11.5	1.0	10.0	1.3	10.4	0.6	10.5	0.7	9.8	0.4	12.0
Healthy User	0.5	5.8	1.7	6.2	2.7	4.5	0.7	5.4	1.1	5.1	0.4	5.7
Low Morbidity	3.9	14.5	12.0	16.8	8.8	17.3	6.2	15.7	3.8	15.3	7.0	15.6
Moderate Morbidity	56.7	49.1	66.2	54.4	59.8	51.3	58.2	52.4	39.0	55.1	67.0	50.4
High Morbidity	24.7	12.2	14.3	9.2	20.6	11.7	22.3	11.5	32.5	10.0	17.5	11.0
Very High Morbidity	13.9	6.9	4.9	3.4	6.7	4.8	12.0	4.5	23.0	4.7	7.6	5.4
Bold values indicate a significant difference between	nificant diffe	erence betwe	een cancer	cancer cohort and matched cancer-free cohort at α = 0.05	matched cã	ancer-free co	short at $\alpha =$: 0.05				

s indicates values suppressed due to small numbers

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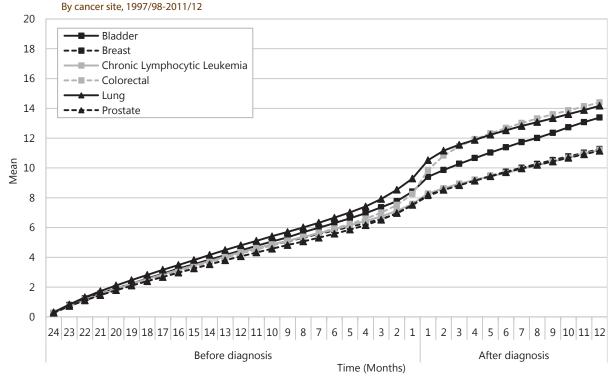
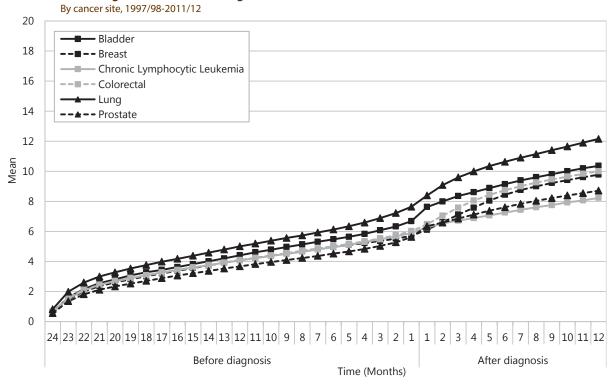


Figure 4.1: Cumulative Mean Number of New Diagnoses for the Cancer Cohort, Excluding Cancer Diagnoses

Figure 4.2: Cumulative Mean Number of New Prescription Drug Dispensations for the Cancer Cohort, Excluding Cancer-Related Drugs



Descriptive Statistics for Health Outcome Measures in the Cancer Cohort

The health outcomes that were investigated in predictive models for the cancer cohort are described in Table 4.6. The overall one-year mortality rate was 25.0%, with the majority of these deaths occurring in hospital. Almost three quarters (73.3%) of the cancer cohort had at least one hospitalization in the one-year period following diagnosis. An incident heart disease diagnosis was rare, with less than one percent of cancer cases having an acute event. Incident diabetes diagnoses occurred in 4.2% of the cancer patients and incident hypertension diagnoses in 16.4% of the cohort. Osteoporosis-related fractures occurred in 1.1% of the cases. In the one-year post-diagnosis period, cancer patients had an average of 13.0 physician visits and 26.4 prescription drug dispensations. However, substantial variation was observed by cancer site. For example, the one-year all-cause mortality rate in lung cancer patients was 62.7%, compared to only 5.5% in breast cancer patients. Only 21.8% of CLL patients were hospitalized in the one-year period following cancer diagnosis compared to 94.4% of patients with colorectal cancer.

Health Outcomes*	Bladder	Breast	Chronic Lymphocytic Leukemia	Colorectal	Lung	Prostate
All-cause Mortality	30.7	5.5	7.9	23.0	62.7	6.1
In-hospital Mortality	21.9	4.3	6.0	16.6	43.0	4.7
Inpatient Hospitalizations	70.1	76.4	21.8	94.4	75.9	56.1
Acute Myocardial Infarction Incidence	1.1	0.4	1.3	0.8	0.8	1.0
Congestive Heart Failure Incidence	4.5	2.3	5.9	5.1	4.7	3.1
Diabetes Incidence	5.0	3.4	4.7	5.5	4.4	3.9
Hypertension Incidence	20.1	13.4	12.4	21.4	17.9	15.9
Osteoporosis-Related Fractures	1.3	1.0	1.2	1.3	1.4	0.8
Ambulatory Physician Visits, mean (SD)	11.5 (8.3)	17.2 (17.2)	11.5 (11.5)	13.3 (13.3)	9.7 (9.7)	12.1 (12.1)
Prescription Drug Dispensations, mean (SD)	26.3 (45.0)	30.4 (30.4)	25.1 (25.1)	26.2 (26.2)	25.9 (25.9)	22.8 (22.8)

Table 4.6: Characteristics of Health Outcomes in the Cancer Cohort By cancer site, 1997/98-2011/12

* all values represent percentages, unless otherwise indicated.

SD indicates standard deviation

Predictive Models for All-Cause Mortality and In-Hospital Mortality

Table 4.7 contains the model fitting results (i.e., c-statistic and Brier score) for all-cause mortality.

The base model c-statistic values ranged from 0.730 for bladder cancer to 0.898 for breast cancer, indicating acceptable to excellent discriminative performance. The Brier score was highest for bladder (0.180) and lung (0.174) cancer in the base model, and lowest for breast (0.037) and prostate (0.052) cancer. A statistically significant increase in the c-statistic was observed for the Elixhauser index for all cancer sites. For other comorbidity measures, the improvement in the c-statistic was not always statistically significant. However, for all of the comorbidity measures, the percentage change in the c-statistic was generally modest. For bladder cancer, it ranged from 0.00% for the Chronic Disease Score to 6.68% for the Elixhauser index. For other cancer sites, the percentage changes were similar or slightly smaller; the exception was for CLL, where the percentage increase for the number of different diagnoses was 2.49%, and for the Elixhauser index it was 8.19%. The Charlson index never resulted in a larger increase in the c-statistic than the Elixhauser index, indicating that the former did not have greater predictive performance than the latter.

In terms of the reclassification statistics (Appendix Table 6.1), there was a statistically significant improvement, as judged by the IDI index, in all comorbidity measures for bladder cancer patients, except for the number of different prescription drugs, number of ADGs[®], and Chronic Disease Score. Only the number of ADGs[®] and Chronic Disease Score did not result in a statistically significant increase in the NRI index. However, the Elixhauser index resulted in the largest numeric values for these two indicators, which is consistent with the findings for the measures of discriminative performance and error.

For other cancer sites, the values for the IDI and NRI indices for one-year mortality were similar to those for bladder cancer. Specifically, the Elixhauser index tended to result in the largest values for the IDI and NRI, indicating improved reclassification. When we explored where the net improvement was achieved, we found it was attributed to a greater number of non-events that were correctly reclassified. See Appendix 7 for the all-cause mortality models that exclude cancer-related causes.

When we examined the results for in-hospital mortality, the findings were very similar for all model statistics; the Elixhauser index had better predictive validity than the other comorbidity measures (Table 4.8 and Appendix Table 6.2). It should be noted, however, that for all cancer sites, the base model for in-hospital mortality had slightly lower predictive performance than the base model for all-cause mortality, as demonstrated by c-statistic values ranging from 0.690 for bladder cancer to 0.792 for CLL. The addition of comorbidity measures to the base model did not result in any of the models producing a c-statistic greater than 0.80, an indicator of excellent discriminative performance.

by currect site, 1997/90 2011/12	c -statistic		
		Brier score	
Models	(95% Confidence		Δc (%)
	Interval)	(Standard Deviation)	
Bladder			
Base	0.730 (0.699, 0.761)	0.180 (0.006)	
No. of diagnoses	0.736 (0.706, 0.766)	0.179 (0.006)	0.007 (0.90)
No. of drugs	0.731 (0.701, 0.762)	0.179 (0.006)	0.002 (0.21)
No. of Aggregated Diagnosis Groups [™]	0.731 (0.701, 0.762)	0.180 (0.006)	0.002 (0.23)
Resource Utilization Bands	0.735 (0.705, 0.766)	0.179 (0.006)	0.006 (0.78)
Chronic Disease Score	0.730 (0.699, 0.760)	0.180 (0.006)	0.000 (-0.01)
Charlson Index	0.739 (0.709, 0.770)	0.177 (0.006)	0.010 (1.32)
Elixhauser Index	0.778 (0.750, 0.807)	0.165 (0.006)	0.049 (6.68)
Breast	0.776 (0.756, 0.667)	0.105 (0.000)	0.045 (0.00)
Base	0.898 (0.883, 0.913)	0.037 (0.002)	
No. of diagnoses	0.901 (0.886, 0.915)	0.037 (0.002)	0.002 (0.26)
No. of drugs	0.901 (0.887, 0.916)	0.037 (0.002)	0.003 (0.34)
No. of Aggregated Diagnosis Groups™	0.900 (0.885, 0.915)	0.037 (0.002)	0.002 (0.20)
Resource Utilization Bands	0.900 (0.885, 0.915)	0.037 (0.002)	0.002 (0.20)
Chronic Disease Score	0.902 (0.887, 0.916)	0.037 (0.002)	0.003 (0.37)
Charlson Index	0.906 (0.892, 0.920)	0.036 (0.001)	0.008 (0.84)
Elixhauser Index	0.910 (0.896, 0.924)	0.036 (0.001)	0.012 (1.31)
Chronic Lymphocytic Leukemia	0.910 (0.890, 0.924)	0.030 (0.001)	0.012 (1.51)
Base	0.786 (0.730, 0.841)	0.065 (0.006)	
No. of diagnoses	0.805 (0.750, 0.841)	0.064 (0.006)	0.020 (2.49)
No. of drugs	0.796 (0.743, 0.849)	0.065 (0.006)	0.020 (2.49)
No. of Aggregated Diagnosis Groups™	0.802 (0.747, 0.857)	0.065 (0.006)	0.016 (2.07)
Resource Utilization Bands	0.806 (0.748, 0.864)		0.010 (2.07)
		0.063 (0.006)	
Chronic Disease Score	0.792 (0.736, 0.847)	0.065 (0.006)	0.006 (0.76)
Charlson Index	0.797 (0.742, 0.852)	0.065 (0.006)	0.011 (1.40)
Elixhauser Index	0.850 (0.800, 0.900)	0.057 (0.006)	0.064 (8.19)
Colorectal Base	0.812 (0.800, 0.824)	0.125 (0.002)	
	0.812 (0.800, 0.824)	0.125 (0.002)	
No. of diagnoses	0.816 (0.804, 0.828)	0.124 (0.002)	0.004 (0.43)
No. of drugs	0.814 (0.802, 0.825)	0.125 (0.002)	0.001 (0.14)
No. of Aggregated Diagnosis Groups™	0.816 (0.804, 0.828)	0.124 (0.002)	0.004 (0.46)
Resource Utilization Bands	0.819 (0.807, 0.831)	0.124 (0.002)	0.007 (0.84)
Chronic Disease Score	0.813 (0.801, 0.825)	0.125 (0.002)	0.001 (0.12)
Charlson Index	0.824 (0.812, 0.836)	0.122 (0.002)	0.012 (1.42)
Elixhauser Index	0.829 (0.818, 0.840)	0.121 (0.002)	0.017 (2.04)
Lung	0.704 (0.774 0.704)	0.174 (0.002)	
Base	0.784 (0.774, 0.794)	0.174 (0.002)	
No. of diagnoses	0.784 (0.774, 0.795)	0.174 (0.002)	0.000 (0.03)
No. of drugs	0.784 (0.774, 0.794)	0.174 (0.002)	0.000 (-0.01)
No. of Aggregated Diagnosis Groups™	0.784 (0.774, 0.794)	0.174 (0.002)	0.000 (0.00)
Resource Utilization Bands	0.784 (0.774, 0.795)	0.174 (0.002)	0.000 (0.03)
Chronic Disease Score	0.784 (0.774, 0.794)	0.174 (0.002)	0.000 (-0.04)
Charlson Index	0.786 (0.776, 0.797)	0.173 (0.002)	0.002 (0.28)
Elixhauser Index	0.792 (0.782, 0.802)	0.171 (0.002)	0.008 (1.04)
Prostate	0.705 (0.772, 0.010)		
Base	0.795 (0.773, 0.816)	0.052 (0.002)	
No. of diagnoses	0.810 (0.789, 0.831)	0.051 (0.002)	0.015 (1.92)
No. of drugs	0.805 (0.783, 0.826)	0.051 (0.002)	0.010 (1.24)
No. of Aggregated Diagnosis Groups™	0.808 (0.787, 0.828)	0.052 (0.002)	0.013 (1.63)
Resource Utilization Bands	0.803 (0.782, 0.825)	0.052 (0.002)	0.009 (1.09)
Chronic Disease Score	0.806 (0.785, 0.826)	0.051 (0.002)	0.011 (1.37)
Charlson Index	0.814 (0.793, 0.834)	0.051 (0.002)	0.019 (2.37)
Elixhauser Index	0.823 (0.803, 0.844)	0.049 (0.002)	0.029 (3.60)

Table 4.7: Measures of Discrimination and Prediction Error for Logistic Regression Models Predicting All-Cause Mortality By cancer site, 1997/98-2011/12

Bold values indicate a statistically significant difference from the base model at α =0.05

Table 4.8: Measures of Discrimination and Prediction Error for Logistic Regression Models Predicting In-Hospital Mortality

By cancer site,	1997/98-2011/12
-----------------	-----------------

by cancer site, 1997/96-2011/12	c -statistic			
		Brier score		
Models	(95% Confidence	(Standard Deviation)	Δc (%)	
	Interval)	(Standard Deviation)		
Bladder				
Base	0.675 (0.637, 0.712)	0.156 (0.006)		
No. of diagnoses	0.684 (0.647, 0.721)	0.156 (0.006)	0.009 (1.34)	
No. of drugs	0.680 (0.642, 0.717)	0.156 (0.006)	0.005 (0.73)	
No. of Aggregated Diagnosis Groups™	0.682 (0.644, 0.719)	0.156 (0.006)	0.007 (1.05)	
Resource Utilization Bands	0.681 (0.644, 0.719)	0.156 (0.006)	0.007 (1.03)	
Chronic Disease Score	0.675 (0.637, 0.713)	0.156 (0.006)	0.000 (0.05)	
Charlson Index	0.685 (0.648, 0.722)	0.156 (0.006)	0.010 (1.50)	
Elixhauser Index	0.724 (0.688, 0.760)	0.148 (0.006)	0.049 (7.29)	
Breast Base	0,800 (0,782, 0,826)	0.025 (0.002)		
No. of diagnoses	0.809 (0.783, 0.836)	0.035 (0.002)		
No. of drugs	0.812 (0.786, 0.838) 0.811 (0.785, 0.837)	0.035 (0.002) 0.035 (0.002)	0.002 (0.26) 0.001 (0.16)	
No. of Aggregated Diagnosis Groups™	0.812 (0.786, 0.838)	0.035 (0.002)	0.002 (0.25)	
Resource Utilization Bands	0.810 (0.784, 0.837)	0.035 (0.002)	0.001 (0.12)	
Chronic Disease Score Charlson Index	0.811 (0.785, 0.837) 0.820 (0.795, 0.846)	0.035 (0.002) 0.034 (0.002)	0.001 (0.17)	
Elixhauser Index	0.820 (0.795, 0.848)	0.034 (0.002)	0.011 (1.34)	
Chronic Lymphocytic Leukemia	0.822 (0.790, 0.848)	0.034 (0.002)	0.015 (1.55)	
Base	0.804 (0.752, 0.855)	0.052 (0.006)		
No. of diagnoses	0.825 (0.773, 0.877)	0.052 (0.000)	0.021 (2.62)	
No. of drugs	0.808 (0.758, 0.858)	0.052 (0.000)	0.004 (0.55)	
No. of Aggregated Diagnosis Groups [™]	0.817 (0.765, 0.868)	0.052 (0.000)	0.004 (0.55)	
Resource Utilization Bands	0.814 (0.761, 0.866)	0.052 (0.000)	0.010 (1.02)	
Chronic Disease Score	0.815 (0.765, 0.864)	0.052 (0.000)	0.010 (1.24)	
Charlson Index	0.824 (0.778, 0.870)	0.052 (0.006)	0.020 (2.48)	
Elixhauser Index	0.854 (0.812, 0.896)	0.051 (0.006)	0.051 (6.30)	
Colorectal	0.031 (0.012, 0.030)	0.031 (0.000)	0.051 (0.50)	
Base	0.776 (0.762, 0.790)	0.114 (0.002)		
No. of diagnoses	0.779 (0.765, 0.793)	0.114 (0.002)	0.003 (0.40)	
No. of drugs	0.777 (0.763, 0.791)	0.114 (0.002)	0.001 (0.09)	
No. of Aggregated Diagnosis Groups™	0.780 (0.766, 0.794)	0.114 (0.002)	0.003 (0.45)	
Resource Utilization Bands	0.782 (0.768, 0.796)	0.114 (0.002)	0.006 (0.73)	
Chronic Disease Score	0.777 (0.763, 0.791)	0.114 (0.002)	0.001 (0.08)	
Charlson Index	0.786 (0.772, 0.800)	0.114 (0.002)	0.009 (1.20)	
Elixhauser Index	0.791 (0.778, 0.805)	0.112 (0.002)	0.015 (1.96)	
Lung				
Base	0.725 (0.714, 0.735)	0.208 (0.002)		
No. of diagnoses	0.725 (0.714, 0.735)	0.208 (0.002)	0.000 (0.00)	
No. of drugs	0.725 (0.714, 0.735)	0.208 (0.002)	0.000 (0.04)	
No. of Aggregated Diagnosis Groups™	0.725 (0.714, 0.735)	0.208 (0.002)	0.000 (0.03)	
Resource Utilization Bands	0.725 (0.714, 0.735)	0.208 (0.002)	0.000 (0.05)	
Chronic Disease Score	0.725 (0.714, 0.735)	0.208 (0.002)	0.000 (0.02)	
Charlson Index	0.725 (0.714, 0.735)	0.208 (0.002)	0.000 (0.05)	
Elixhauser Index	0.731 (0.720, 0.741)	0.206 (0.002)	0.006 (0.83)	
Prostate				
Base	0.745 (0.718, 0.773)	0.043 (0.002)		
No. of diagnoses	0.759 (0.732, 0.786)	0.042 (0.002)	0.013 (1.78)	
No. of drugs	0.753 (0.726, 0.780)	0.042 (0.002)	0.008 (1.02)	
No. of Aggregated Diagnosis Groups™	0.760 (0.733, 0.787)	0.042 (0.002)	0.015 (1.98)	
Resource Utilization Bands	0.754 (0.727, 0.782)	0.042 (0.002)	0.009 (1.21)	
Chronic Disease Score	0.753 (0.726, 0.780)	0.042 (0.002)	0.008 (1.04)	
Charlson Index	0.764 (0.737, 0.790)	0.042 (0.002)	0.018 (2.42)	
Elixhauser Index Bold values indicate a statistically significant diff	0.772 (0.745, 0.799)	0.041 (0.002)	0.027 (3.56)	

Bold values indicate a statistically significant difference from the base model at α =0.05

Table 4.9 contains the results of the predictive models for hospitalization in the one-year period following cancer diagnosis. The base model c-statistics varied substantially, from 0.664 for bladder to 0.830 for lung, indicating poor to excellent predictive validity. Brier score values were high for all models, with the exception of those for colorectal cancer, which were less than 0.05. When each comorbidity measure was added to the base model, the absolute magnitude of change in the c-statistic varied slightly across cancer sites, but was always largest for the Elixhauser index. For the reclassification statistics (Appendix Table 6.3), the IDI and NRI did not always produce consistent results, particularly for breast cancer. The NRI was more likely to demonstrate a statistically significant change in reclassification performance than the IDI.

TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER CREATOR EXP

Tables 4.10 and 4.11 contain the results of the predictive models for ambulatory physician visits and prescription drug dispensations. For the former, the pseudo–R2 values for the base model ranged from 0.149 for prostate cancer to 0.658 for lung cancer, while the RMSE values ranged from 6.21 for lung cancer to 7.85 for breast cancer. For the latter, the pseudo–R2 values ranged from 0.108 for prostate cancer to 0.408 for lung cancer while the RMSE values were substantially larger, and ranged from 27.12 for prostate cancer to 43.00 for bladder cancer.

In the predictive models for ambulatory physician visits amongst bladder cancer patients, the pseudo–R2 values increased from 2.31% (Charlson index) to 12.66% (number of ADGs[®]) as comorbidity measures were added to the base model. The RMSE decreased for all comorbidity measures, but the percentage changes were modest (0.90% for the Charlson index; 5.13% for the number of different prescription drugs). The percentage changes for the pseudo–R2 values were smaller for colorectal and lung cancer than for bladder cancer; they favoured the number of different drugs, or number of ADGs[®]. The Charlson index performed the poorest in terms of explained variation in the full models.

For breast, prostate, and CLL cancers, the change in pseudo–R2 values was substantially larger for the ambulatory physician visit models. For example, for CLL, they ranged from 19.09% for the Charlson index to 106.60% for the number of different diagnoses. For the latter comorbidity measure, the full model had a pseudo–R2 value of 0.380. The reductions in the RMSE were small as comorbidity measures were added to the base model.

In the bladder cancer predictive models for prescription drug dispensations, the pseudo–R2 values increased by 27.01% (Charlson index) to 81.97% (Elixhauser index). However, as we observed for ambulatory physician visits, decreases in the RMSE values were modest; they ranged from 2.02% (Charlson index) to 6.93% (Elixhauser index). For other cancer sites, the improvements in predictive performance of the models that included the comorbidity measures varied substantially. They were small for lung cancer, but as noted previously, the base model had the highest predictive performance. The improvements were largest for breast and prostate cancer, for which the base models had the lowest predictive performance. For all cancer sites, the Elixhauser index resulted in the largest improvements in both predictive performance and RMSE values.

Table 4.9: Measures of Discrimination and Prediction Error for Logistic Regression Models Predicting **Incident Hospitalization** By cancer site, 1997/98-2011/12

	<i>c</i> -statistic			
Models	(95% Confidence	Brier score	Δc (%)	
	Interval)	(Standard Deviation)		
Bladder	Interval)			
Base	0.664 (0.626, 0.703)	0.196 (0.006)		
No. of diagnoses	0.675 (0.637, 0.713)	0.194 (0.006)	0.011 (1.60)	
No. of drugs	0.671 (0.633, 0.709)	0.195 (0.006)	0.006 (0.94)	
No. of Aggregated Diagnosis Groups™	0.672 (0.634, 0.710)	0.195 (0.006)	0.008 (1.20)	
Resource Utilization Bands	0.670 (0.632, 0.708)	0.195 (0.006)	0.006 (0.87)	
Chronic Disease Score	0.666 (0.627, 0.704)	0.196 (0.006)	0.001 (0.18)	
Charlson Index	0.668 (0.630, 0.706)	0.195 (0.006)	0.004 (0.55)	
Elixhauser Index	0.690 (0.653, 0.727)	0.190 (0.006)	0.026 (3.85)	
Breast			1	
Base	0.698 (0.685, 0.711)	0.166 (0.002)		
No. of diagnoses	0.701 (0.687, 0.714)	0.166 (0.002)	0.002 (0.34)	
No. of drugs	0.699 (0.686, 0.712)	0.166 (0.002)	0.001 (0.11)	
No. of Aggregated Diagnosis Groups™	0.701 (0.688, 0.714)	0.166 (0.002)	0.003 (0.40)	
Resource Utilization Bands	0.700 (0.687, 0.713)	0.166 (0.002)	0.002 (0.24)	
Chronic Disease Score	0.698 (0.685, 0.711)	0.166 (0.002)	0.000 (0.04)	
Charlson Index	0.703 (0.690, 0.716)	0.165 (0.002)	0.005 (0.66)	
Elixhauser Index	0.710 (0.697, 0.723)	0.163 (0.002)	0.012 (1.69)	
Chronic Lymphocytic Leukemia	0.741 (0.607, 0.784)	0 1 4 8 (0 0 0 7)	1	
Base No. of diagnoses	0.741 (0.697, 0.784)	0.148 (0.007)		
No. of drugs	0.748 (0.705, 0.790) 0.757 (0.715, 0.798)	0.147 (0.007) 0.145 (0.007)	0.007 (0.94) 0.016 (2.16)	
No. of Aggregated Diagnosis Groups [™]	0.746 (0.704, 0.789)	0.145 (0.007)	0.016 (2.16)	
Resource Utilization Bands	0.743 (0.701, 0.785)	0.147 (0.007)	0.003 (0.74)	
Chronic Disease Score	0.754 (0.713, 0.795)	0.146 (0.007)	0.014 (1.84)	
Charlson Index	0.747 (0.705, 0.789)	0.147 (0.007)	0.006 (0.87)	
Elixhauser Index	0.775 (0.734, 0.817)	0.147 (0.007)	0.035 (4.70)	
Colorectal	0.775 (0.754, 0.017)	0.130 (0.007)	0.033 (4.70)	
Base	0.809 (0.787, 0.831)	0.048 (0.002)		
No. of diagnoses	0.812 (0.790, 0.834)	0.047 (0.002)	0.003 (0.33)	
No. of drugs	0.809 (0.787, 0.831)	0.048 (0.002)	0.000 (-0.01)	
No. of Aggregated Diagnosis Groups™	0.812 (0.791, 0.834)	0.048 (0.002)	0.003 (0.40)	
Resource Utilization Bands	0.818 (0.797, 0.840)	0.047 (0.002)	0.009 (1.16)	
Chronic Disease Score	0.809 (0.786, 0.831)	0.048 (0.002)	0.000 (-0.06)	
Charlson Index	0.817 (0.795, 0.838)	0.047 (0.002)	0.008 (0.94)	
Elixhauser Index	0.844 (0.825, 0.863)	0.046 (0.002)	0.035 (4.33)	
Lung		· · · ·		
Base	0.830 (0.816, 0.844)	0.135 (0.002)		
No. of diagnoses	0.837 (0.823, 0.851)	0.133 (0.002)	0.007 (0.89)	
No. of drugs	0.834 (0.820, 0.848)	0.133 (0.002)	0.004 (0.53)	
No. of Aggregated Diagnosis Groups [™]	0.835 (0.821, 0.849)	0.134 (0.002)	0.005 (0.59)	
Resource Utilization Bands	0.831 (0.817, 0.845)	0.135 (0.002)	0.002 (0.21)	
Chronic Disease Score	0.835 (0.820, 0.849)	0.134 (0.002)	0.005 (0.59)	
Charlson Index	0.831 (0.817, 0.845)	0.134 (0.002)	0.002 (0.21)	
_ Elixhauser Index	0.844 (0.831, 0.858)	0.131 (0.002)	0.015 (1.77)	
Prostate			1	
Base	0.828 (0.818, 0.838)	0.154 (0.003)		
No. of diagnoses	0.830 (0.820, 0.840)	0.153 (0.003)	0.002 (0.22)	
No. of drugs	0.830 (0.820, 0.840)	0.154 (0.003)	0.002 (0.20)	
No. of Aggregated Diagnosis Groups™	0.829 (0.819, 0.839)	0.154 (0.003)	0.001 (0.13)	
Resource Utilization Bands	0.830 (0.820, 0.840)	0.153 (0.003)	0.002 (0.24)	
Chronic Disease Score	0.830 (0.820, 0.840)	0.154 (0.003)	0.002 (0.22)	
Charlson Index	0.830 (0.820, 0.840)	0.154 (0.003)	0.002 (0.29)	
Elixhauser Index	0.840 (0.830, 0.850)	0.150 (0.003)	0.012 (1.43)	

Bold values indicate a statistically significant difference from the base model at α =0.05

Models	R ²	Δ R ² (%)	RMSE	Abs ΔRMSE (%)
Bladder				
Base	0.413		6.79	
No. of diagnoses	0.464	0.05 (12.49)	6.45	0.34 (5.04)
No. of drugs	0.464	0.05 (12.50)	6.44	0.35 (5.13)
No. of Aggregated Diagnosis Groups [™]	0.465	0.05 (12.66)	6.44	0.35 (5.22)
Resource Utilization Bands	0.438	0.03 (6.23)	6.61	0.18 (2.61)
Chronic Disease Score	0.462	0.05 (11.85)	6.46	0.33 (4.86)
Charlson Index	0.422	0.01 (2.31)	6.73	0.06 (0.90)
Elixhauser Index	0.463	0.05 (12.31)	6.45	0.34 (4.97)
Breast				
Base	0.239		7.85	
No. of diagnoses	0.359	0.12 (49.78)	7.24	0.61 (7.77)
No. of drugs	0.347	0.11 (44.94)	7.29	0.56 (7.15)
No. of Aggregated Diagnosis Groups™	0.352	0.11 (47.05)	7.26	0.59 (7.54)
Resource Utilization Bands	0.285	0.05 (19.14)	7.63	0.22 (2.75)
Chronic Disease Score	0.324	0.08 (35.24)	7.42	0.43 (5.50)
Charlson Index	0.244	0.00 (1.89)	7.83	0.02 (0.25)
Elixhauser Index	0.318	0.08 (32.88)	7.45	0.39 (5.02)
Chronic Lymphocytic Leukemia				
Base	0.184		7.38	
No. of diagnoses	0.380	0.20 (106.60)	6.50	0.89 (12.03)
No. of drugs	0.337	0.15 (83.43)	6.70	0.69 (9.28)
No. of Aggregated Diagnosis Groups™	0.358	0.17 (94.98)	6.53	0.85 (11.53)
Resource Utilization Bands	0.253	0.07 (37.55)	7.09	0.29 (3.93)
Chronic Disease Score	0.317	0.13 (72.39)	6.76	0.62 (8.40)
Charlson Index	0.219	0.04 (19.09)	7.21	0.17 (2.35)
Elixhauser Index	0.319	0.13 (73.26)	6.74	0.65 (8.76)
Colorectal				
Base	0.486		7.61	
No. of diagnoses	0.517	0.03 (6.38)	7.39	0.23 (2.97)
No. of drugs	0.522	0.04 (7.27)	7.36	0.26 (3.37)
No. of Aggregated Diagnosis Groups™	0.517	0.03 (6.34)	7.38	0.23 (3.08)
Resource Utilization Bands	0.496	0.01 (2.02)	7.54	0.07 (0.92)
Chronic Disease Score	0.516	0.03 (6.18)	7.39	0.22 (2.90)
Charlson Index	0.489	0.00 (0.60)	7.59	0.02 (0.26)
Elixhauser Index	0.515	0.03 (5.95)	7.39	0.22 (2.95)
Lung				
Base	0.658		6.21	
No. of diagnoses	0.679	0.02 (3.16)	5.94	0.27 (4.33)
No. of drugs	0.675	0.02 (2.58)	6.00	0.21 (3.37)
No. of Aggregated Diagnosis Groups™	0.678	0.02 (2.98)	5.97	0.24 (3.89)
Resource Utilization Bands	0.665	0.01 (0.99)	6.14	0.07 (1.14)
Chronic Disease Score	0.670	0.01 (1.84)	6.07	0.14 (2.33)
Charlson Index	0.659	0.00 (0.15)	6.20	0.01 (0.23)
Elixhauser Index	0.670	0.01 (1.78)	6.07	0.14 (2.29)
Prostate				()
Base	0.149		6.54	
No. of diagnoses	0.270	0.12 (81.53)	6.07	0.47 (7.18)
No. of drugs	0.254	0.10 (70.41)	6.12	0.42 (6.44)
No. of Aggregated Diagnosis Groups™	0.255	0.11 (71.36)	6.11	0.43 (6.58)
Resource Utilization Bands	0.190	0.04 (27.37)	6.39	0.15 (2.36)
Chronic Disease Score	0.236	0.09 (58.74)	6.20	0.34 (5.20)
Charlson Index	0.160	0.01 (7.68)	6.49	0.05 (0.72)
Elixhauser Index	0.229	0.08 (53.73)	6.22	0.32 (4.86)

Table 4.10: Measures of Explained Variation and Error for Negative Binomial Models Predicting Ambulatory Physician Visit Rates By cancer site, 1997/98-2011/12

Bold values indicate a statistically significant difference from the base model at α =0.05

RMSE indicates Root-Mean-Square Error

Table 4.11: Measures of Explained Variation and Error for Negative Binomial Models Predicting Prescription Drug Rates By cancer site, 1997/98-2011/12

Models	R ²	Δ R ² (%)	RMSE	Abs ΔRMSE (%)
Bladder	1			
Base	0.198		43.00	
No. of diagnoses	0.306	0.11 (54.18)	41.50	1.50 (3.48)
No. of Aggregated Diagnosis Groups™	0.286	0.09 (44.29)	41.72	1.28 (2.98)
Resource Utilization Bands	0.275	0.08 (38.82)	41.79	1.21 (2.81)
Charlson Index	0.252	0.05 (27.01)	42.13	0.87 (2.02)
Elixhauser Index	0.361	0.16 (81.97)	40.02	2.98 (6.93)
Breast				
Base	0.111		35.21	
No. of diagnoses	0.229	0.12 (107.53)	34.20	1.01 (2.87)
No. of Aggregated Diagnosis Groups™	0.221	0.11 (100.36)	33.72	1.49 (4.23)
Resource Utilization Bands	0.196	0.09 (77.65)	34.07	1.14 (3.23)
Charlson Index	0.141	0.03 (27.19)	34.99	0.22 (0.62)
Elixhauser Index	0.261	0.15 (136.33)	34.13	1.07 (3.05)
Chronic Lymphocytic Leukemia				
Base	0.117		35.41	
No. of diagnoses	0.228	0.11 (95.09)	34.58	0.84 (2.36)
No. of Aggregated Diagnosis Groups™	0.198	0.08 (69.96)	35.11	0.30 (0.85)
Resource Utilization Bands	0.184	0.07 (57.49)	34.50	0.91 (2.57)
Charlson Index	0.174	0.06 (49.02)	34.47	0.94 (2.66)
Elixhauser Index	0.327	0.21 (180.36)	32.47	2.95 (8.32)
Colorectal				
Base	0.205		33.14	
No. of diagnoses	0.293	0.09 (42.93)	31.96	1.18 (3.57)
No. of Aggregated Diagnosis Groups™	0.271	0.07 (32.28)	32.14	0.99 (3.00)
Resource Utilization Bands	0.250	0.05 (22.02)	32.48	0.66 (1.98)
Charlson Index	0.240	0.03 (16.96)	32.65	0.48 (1.46)
Elixhauser Index	0.345	0.14 (67.95)	31.16	1.98 (5.96)
Lung				
Base	0.408		32.27	
No. of diagnoses	0.467	0.06 (14.27)	30.71	1.56 (4.82)
No. of Aggregated Diagnosis Groups™	0.451	0.04 (10.47)	31.23	1.04 (3.22)
Resource Utilization Bands	0.434	0.03 (6.19)	31.69	0.57 (1.78)
Charlson Index	0.426	0.02 (4.26)	31.88	0.38 (1.19)
Elixhauser Index	0.492	0.08 (20.56)	30.02	2.25 (6.98)
Prostate				
Base	0.108		27.12	
No. of diagnoses	0.222	0.11 (105.53)	26.09	1.03 (3.79)
No. of Aggregated Diagnosis Groups™	0.188	0.08 (74.17)	26.21	0.90 (3.33)
Resource Utilization Bands	0.172	0.06 (59.34)	26.32	0.80 (2.94)
Charlson Index	0.162	0.05 (49.99)	26.50	0.61 (2.27)
Elixhauser Index	0.288	0.18 (167.19)	25.76	1.36 (5.00)

Bold values indicate a statistically significant difference from the base model at α =0.05

RMSE indicates Root-Mean-Square Error

Predictive Models for Acute and Chronic Health Outcomes

Hypertension

Table 4.12 contains the model results (c-statistics and Brier scores) for predicting incident hypertension cases in the cancer cohort. The base model had c-statistic values ranging from 0.570 (prostate cancer) to 0.736 (breast cancer); indicating poor to acceptable discriminative performance of the base model. Brier scores for the base model ranged from 0.104 (CLL) to 0.159 (colorectal cancer). The full models that contained the comorbidity measures resulted in modest increases in c-statistic values; only a few of the increases were greater than 10%. For example, for lung cancer, the Elixhauser index resulted in a 12.52% increase in the c-statistic. For prostate cancer, the number of different prescription drugs resulted in a 12.89% increase and the Chronic Disease Score resulted in a 13.98% increase.

In terms of the reclassification statistics (Appendix Table 6.4), they were statistically significant for all cancer sites for both the Elixhauser index and the Chronic Disease Score. However, it was only the latter that resulted in positive values for reclassification of both positive and negative events; in contrast, the Elixhauser index tended to produce only positive reclassification for non–events, indicating that it did a better job at improving predictive performance for individuals who did not have hypertension.

·	c -statistic		
Medele		Brier score	A = (9/)
Models	(95% Confidence	(Standard Deviation)	Δc (%)
	Interval)		
Bladder	0.710 (0.651.0.760)	0.1.47 (0.010)	
Base	0.710 (0.651, 0.768)	0.147 (0.010)	
No. of diagnoses	0.720 (0.662, 0.778)	0.145 (0.010)	0.011 (1.51)
No. of drugs	0.743 (0.685, 0.800)	0.139 (0.010)	0.033 (4.67)
No. of Aggregated Diagnosis Groups™	0.720 (0.662, 0.779)	0.145 (0.010)	0.011 (1.52)
Resource Utilization Bands	0.711 (0.652, 0.769)	0.147 (0.010)	0.001 (0.16)
Chronic Disease Score	0.736 (0.679, 0.793)	0.140 (0.010)	0.026 (3.71)
Charlson Index	0.712 (0.653, 0.771)	0.146 (0.010)	0.003 (0.38)
Elixhauser Index	0.731 (0.671, 0.792)	0.139 (0.010)	0.022 (3.04)
Breast			
Base	0.736 (0.717, 0.754)	0.107 (0.003)	
No. of diagnoses	0.739 (0.721, 0.758)	0.107 (0.003)	0.004 (0.51)
No. of drugs	0.753 (0.735, 0.772)	0.105 (0.003)	0.018 (2.38)
No. of Aggregated Diagnosis Groups™	0.738 (0.719, 0.757)	0.107 (0.003)	0.002 (0.31)
Resource Utilization Bands	0.738 (0.719, 0.757)	0.107 (0.003)	0.003 (0.34)
Chronic Disease Score	0.763 (0.745, 0.781)	0.104 (0.003)	0.027 (3.72)
Charlson Index	0.738 (0.719, 0.757)	0.107 (0.003)	0.002 (0.31)
Elixhauser Index	0.764 (0.746, 0.782)	0.103 (0.003)	0.029 (3.87)
Chronic Lymphocytic Leukemia			
Base	0.666 (0.589, 0.743)	0.104 (0.011)	
No. of diagnoses	0.667 (0.590, 0.744)	0.104 (0.011)	0.001 (0.14)
No. of drugs	0.698 (0.620, 0.776)	0.101 (0.010)	0.032 (4.75)
No. of Aggregated Diagnosis Groups [™]	0.668 (0.591, 0.745)	0.104 (0.011)	0.002 (0.29)
Resource Utilization Bands	0.664 (0.587, 0.741)	0.104 (0.011)	-0.002 (-0.32)
Chronic Disease Score	0.696 (0.621, 0.772)	0.101 (0.010)	0.030 (4.55)
Charlson Index	0.667 (0.590, 0.744)	0.104 (0.011)	0.001 (0.12)
Elixhauser Index	0.687 (0.606, 0.768)	0.100 (0.010)	0.021 (3.14)
Colorectal			
Base	0.662 (0.640, 0.685)	0.159 (0.004)	
No. of diagnoses	0.671 (0.649, 0.693)	0.158 (0.004)	0.009 (1.29)
No. of drugs	0.713 (0.692, 0.735)	0.151 (0.004)	0.051 (7.71)
No. of Aggregated Diagnosis Groups™	0.665 (0.643, 0.687)	0.159 (0.004)	0.003 (0.39)
Resource Utilization Bands	0.664 (0.642, 0.686)	0.159 (0.004)	0.002 (0.27)
Chronic Disease Score	0.730 (0.709, 0.751)	0.148 (0.004)	0.068 (10.26)
Charlson Index	0.670 (0.648, 0.692)	0.158 (0.004)	0.008 (1.15)
Elixhauser Index	0.719 (0.697, 0.741)	0.149 (0.004)	0.057 (8.55)
Lung			
Base	0.659 (0.621, 0.696)	0.140 (0.006)	
No. of diagnoses	0.676 (0.639, 0.713)	0.139 (0.006)	0.017 (2.62)
No. of drugs	0.713 (0.676, 0.750)	0.133 (0.006)	0.054 (8.19)
No. of Aggregated Diagnosis Groups™	0.669 (0.631, 0.706)	0.140 (0.006)	0.010 (1.51)
Resource Utilization Bands	0.669 (0.630, 0.707)	0.139 (0.006)	0.010 (1.49)
Chronic Disease Score	0.721 (0.684, 0.759)	0.131 (0.006)	0.062 (9.47)
Charlson Index	0.669 (0.631, 0.707)	0.139 (0.006)	0.011 (1.60)
Elixhauser Index	0.741 (0.707, 0.776)	0.130 (0.006)	0.082 (12.52)
Prostate		0.100 (0.000)	5.00E (EE.0E)
Base	0.570 (0.546, 0.593)	0.133 (0.004)	
No. of diagnoses	0.589 (0.565, 0.612)	0.132 (0.004)	0.019 (3.34)
No. of drugs	0.643 (0.619, 0.667)	0.132 (0.004)	0.073 (12.89)
No. of Aggregated Diagnosis Groups [™]	0.587 (0.563, 0.611)	0.132 (0.004)	0.017 (3.01)
Resource Utilization Bands	0.571 (0.547, 0.594)	0.132 (0.004)	0.001 (0.17)
Chronic Disease Score	0.649 (0.626, 0.673)	0.128 (0.004)	0.080 (13.98)
Charlson Index	0.570 (0.547, 0.594)	0.128 (0.004)	0.001 (0.10)
Elixhauser Index	0.623 (0.599, 0.647)	0.133 (0.004)	0.053 (9.33)
	0.023 (0.333, 0.047)	0.130 (0.004)	0.033 (3.33)

Table 4.12: Measures of Discrimination and Prediction Error for Logistic Regression Models Predicting Incident Hypertension By cancer site, 1997/98-2011/12

Bold values indicate a statistically significant difference from the base model at α =0.05

For diabetes (Table 4.13) in terms of the c–statistics and Brier scores, the base logistic regression models for all cancer sites had poor to acceptable discriminative performance; c–statistics ranged from 0.577 for prostate cancer to 0.721 for CLL. However, compared with Brier scores for the hypertension base models, the Brier scores for diabetes were substantially lower and indicated little prediction error in the base models. Values of the Brier score were lowest for the base model for breast cancer (0.032). Across all cancer sites, the Elixhauser index resulted in the greatest improvements in predictive performance with percentage values ranging from 2.42% (bladder cancer) to 14.04% (lung cancer). The Brier scores changed little, if any, when the comorbidity measures were added to the models.

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The reclassification statistics (Appendix Table 6.5) revealed improvements only for the Elixhauser index for bladder, breast, and lung cancer. For breast cancer, the NRI was also statistically significant for the Chronic Disease Score. For CLL, the IDI was statistically significant for both the Chronic Disease Score and the Elixhauser index, while the NRI was statistically significantly only for the former. For colorectal cancer, the IDI and NRI were statistically significant for the number of different drugs, Chronic Disease Score, and Elixhauser index. For prostate cancer, only the number of ADGs[®] and the Charlson index did not result in a statistically significant result for the IDI statistic. Conversely, the Chronic Disease Score and Elixhauser index were the only comorbidity measures that resulted in significant change in the NRI statistic, indicating there was reclassification improvement with both measures.

By cancer site, 1997/98-2011/12		1	1
Models	<i>c</i> -statistic (95% Confidence Interval)	Brier score (Standard Deviation)	Δc (%)
Bladder	Interval)		
Base	0.724 (0.624, 0.823)	0.046 (0.008)	
No. of diagnoses	0.725 (0.626, 0.823)	0.046 (0.008)	0.001 (0.16)
No. of drugs	0.729 (0.628, 0.830)	0.046 (0.008)	0.006 (0.76)
No. of Aggregated Diagnosis Groups™	0.724 (0.624, 0.823)	0.046 (0.008)	0.000 (0.01)
Resource Utilization Bands	0.724 (0.625, 0.823)	0.046 (0.008)	0.000 (0.07)
Chronic Disease Score	0.730 (0.628, 0.831)	0.046 (0.008)	0.006 (0.83)
Charlson Index	0.724 (0.624, 0.823)	0.046 (0.008)	0.000 (0.03)
Elixhauser Index	0.741 (0.645, 0.837)	0.044 (0.007)	0.018 (2.42)
Breast			
Base	0.619 (0.584, 0.655)	0.032 (0.002)	
No. of diagnoses	0.619 (0.584, 0.655)	0.032 (0.002)	0.000 (0.03)
No. of drugs	0.650 (0.615, 0.685)	0.032 (0.002)	0.031 (5.01)
No. of Aggregated Diagnosis Groups™	0.619 (0.584, 0.655)	0.032 (0.002)	0.000 (-0.01)
Resource Utilization Bands	0.619 (0.583, 0.654)	0.032 (0.002)	-0.001 (-0.11)
Chronic Disease Score	0.663 (0.628, 0.699)	0.032 (0.002)	0.044 (7.13)
Charlson Index	0.619 (0.584, 0.655)	0.032 (0.002)	0.000 (0.02)
Elixhauser Index	0.692 (0.658, 0.726)	0.032 (0.002)	0.073 (11.78)
Chronic Lymphocytic Leukemia	· · · · ·	· · · ·	
Base	0.721 (0.624, 0.817)	0.044 (0.007)	
No. of diagnoses	0.721 (0.625, 0.818)	0.044 (0.007)	0.001 (0.09)
No. of drugs	0.723 (0.631, 0.815)	0.044 (0.007)	0.003 (0.37)
No. of Aggregated Diagnosis Groups™	0.722 (0.627, 0.818)	0.044 (0.007)	0.001 (0.18)
Resource Utilization Bands	0.721 (0.623, 0.820)	0.044 (0.007)	0.001 (0.08)
Chronic Disease Score	0.747 (0.659, 0.835)	0.043 (0.007)	0.026 (3.63)
Charlson Index	0.724 (0.626, 0.822)	0.044 (0.007)	0.003 (0.41)
Elixhauser Index	0.771 (0.689, 0.853)	0.042 (0.007)	0.050 (6.99)
Colorectal			
Base	0.607 (0.573, 0.642)	0.052 (0.003)	
No. of diagnoses	0.611 (0.576, 0.646)	0.052 (0.003)	0.004 (0.58)
No. of drugs	0.652 (0.615, 0.688)	0.051 (0.003)	0.044 (7.26)
No. of Aggregated Diagnosis Groups™	0.612 (0.578, 0.647)	0.052 (0.003)	0.005 (0.79)
Resource Utilization Bands	0.608 (0.573, 0.643)	0.052 (0.003)	0.001 (0.11)
Chronic Disease Score	0.653 (0.617, 0.688)	0.051 (0.003)	0.045 (7.44)
Charlson Index	0.609 (0.574, 0.644)	0.052 (0.003)	0.001 (0.22)
Elixhauser Index	0.648 (0.613, 0.684)	0.051 (0.003)	0.041 (6.73)
Lung			
Base	0.640 (0.578, 0.702)	0.042 (0.004)	
No. of diagnoses	0.642 (0.580, 0.704)	0.042 (0.004)	0.002 (0.30)
No. of drugs	0.646 (0.586, 0.707)	0.042 (0.004)	0.007 (1.02)
No. of Aggregated Diagnosis Groups™	0.653 (0.592, 0.714)	0.042 (0.004)	0.013 (2.00)
Resource Utilization Bands	0.641 (0.580, 0.702)	0.042 (0.004)	0.001 (0.17)
Chronic Disease Score	0.651 (0.589, 0.712)	0.042 (0.004)	0.011 (1.71)
Charlson Index	0.640 (0.578, 0.702)	0.042 (0.004)	0.000 (0.06)
Elixhauser Index	0.730 (0.670, 0.790)	0.038 (0.004)	0.090 (14.04)
Prostate	0.577 (0.520, 0.614)	0.038 (0.002)	
Base No. of diagnoses	0.577 (0.539, 0.614)	0.038 (0.002)	
	0.591 (0.554, 0.628)	0.038 (0.002)	0.014 (2.46)
No. of drugs No. of Aggregated Diagnosis Groups™	0.627 (0.590, 0.665)		0.001 (8.76)
Resource Utilization Bands	0.586 (0.549, 0.624) 0.588 (0.550, 0.626)	0.038 (0.002)	0.009 (1.61) 0.011 (1.98)
Chronic Disease Score	0.648 (0.610, 0.686)	0.038 (0.002) 0.037 (0.002)	0.011 (1.98)
Chirofic Disease Score Charlson Index	0.585 (0.548, 0.622)	0.037 (0.002)	0.008 (1.39)
Elixhauser Index	0.585 (0.548, 0.622)	0.038 (0.002)	0.008 (1.39) 0.066 (11.37)
	U.042 (U.0U3, U.00U)	0.057 (0.002)	0.000(11.57)

Table 4.13: Measures of Discrimination and Prediction Error for Logistic Regression Models Predicting Incident Diabetes By cancer site, 1997/98-2011/12

Bold values indicate a statistically significant difference from the base model at α =0.05

Congestive Heart Failure

For this chronic condition (Table 4.14), the base models for all cancer sites had c-statistic values that ranged from 0.735 (lung cancer) to 0.810 (CLL), indicating acceptable to very good discriminative performance. The values of the Brier scores were also low for all base models, and ranged from 0.022 for breast cancer to 0.050 for CLL. In terms of the full models that contained comorbidity measures, the improvements in c-statistics were consistently largest for the Elixhauser index; the percentage improvements ranged from 3.89% for prostate cancer to 10.25% for lung cancer. The Brier scores for the full models were also lowest for the Elixhauser index. The Chronic Disease Score and the number of different drugs resulted in larger increases in the c-statistic for all cancer sites than other comorbidity measures.

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These results for discriminative performance and prediction error are consistent with the reclassification statistic results (Appendix Table 6.6), which revealed statistically significant improvements for the IDI and NRI for these comorbidity measures across all cancer sites. For colorectal cancer, statistically significant values of the IDI were observed for all comorbidity measures except the Charlson index. Statistically significant values of the NRI were also observed for all but the Charlson index and number of ADGs[®].

Table 4.14: Measures of Discrimination and Prediction Error for Logistic Regression Models Predicting Incident Congestive Heart Failure By cancer site, 1997/98-2011/12

By cancer site, 1997/98-2011/12				
		Brier score		
Models	(95% Confidence	(Standard Deviation)	Δc (%)	
	Interval)	(Standard Deviation)		
Bladder				
Base	0.780 (0.710, 0.850)	0.041 (0.007)		
No. of diagnoses	0.781 (0.709, 0.852)	0.040 (0.006)	0.000 (0.05)	
No. of drugs	0.803 (0.733, 0.873)	0.039 (0.006)	0.023 (2.96)	
No. of Aggregated Diagnosis Groups™	0.780 (0.711, 0.850)	0.041 (0.007)	0.000 (0.01)	
Resource Utilization Bands	0.782 (0.713, 0.851)	0.041 (0.006)	0.002 (0.23)	
Chronic Disease Score	0.801 (0.732, 0.870)	0.038 (0.006)	0.021 (2.67)	
Charlson Index	0.780 (0.711, 0.850)	0.041 (0.007)	0.000 (0.04)	
Elixhauser Index	0.817 (0.753, 0.882)	0.040 (0.006)	0.037 (4.77)	
Breast			1	
Base	0.799 (0.769, 0.829)	0.022 (0.002)		
No. of diagnoses	0.811 (0.782, 0.841)	0.022 (0.002)	0.012 (1.55)	
No. of drugs	0.836 (0.809, 0.863)	0.022 (0.001)	0.037 (4.65)	
No. of Aggregated Diagnosis Groups™	0.811 (0.782, 0.841)	0.022 (0.002)	0.012 (1.56)	
Resource Utilization Bands	0.819 (0.790, 0.848)	0.022 (0.002)	0.020 (2.50)	
Chronic Disease Score	0.831 (0.803, 0.858)	0.022 (0.001)	0.032 (3.96)	
Charlson Index	0.820 (0.793, 0.848)	0.022 (0.002)	0.021 (2.68)	
Elixhauser Index	0.851 (0.825, 0.877)	0.021 (0.001)	0.052 (6.53)	
Chronic Lymphocytic Leukemia				
Base	0.810 (0.744, 0.876)	0.050 (0.006)		
No. of diagnoses	0.813 (0.748, 0.878)	0.050 (0.006)	0.003 (0.34)	
No. of drugs	0.821 (0.758, 0.884)	0.049 (0.006)	0.011 (1.30)	
No. of Aggregated Diagnosis Groups™	0.812 (0.747, 0.878)	0.050 (0.006)	0.002 (0.26)	
Resource Utilization Bands	0.812 (0.747, 0.877)	0.050 (0.006)	0.002 (0.23)	
Chronic Disease Score	0.828 (0.765, 0.890)	0.049 (0.006)	0.018 (2.17)	
Charlson Index	0.811 (0.745, 0.877)	0.050 (0.006)	0.001 (0.13)	
Elixhauser Index	0.847 (0.787, 0.906)	0.047 (0.006)	0.037 (4.50)	
Colorectal				
Base	0.753 (0.725, 0.781)	0.046 (0.003)		
No. of diagnoses	0.757 (0.729, 0.785)	0.046 (0.003)	0.004 (0.47)	
No. of drugs	0.775 (0.748, 0.801)	0.046 (0.002)	0.022 (2.88)	
No. of Aggregated Diagnosis Groups™	0.755 (0.727, 0.783)	0.046 (0.003)	0.001 (0.18)	
Resource Utilization Bands	0.758 (0.730, 0.786)	0.046 (0.003)	0.005 (0.64)	
Chronic Disease Score	0.776 (0.749, 0.802)	0.046 (0.002)	0.022 (2.97)	
Charlson Index	0.757 (0.729, 0.785)	0.046 (0.003)	0.003 (0.45)	
Elixhauser Index	0.784 (0.758, 0.810)	0.045 (0.002)	0.031 (4.10)	
Lung			0.001 (1120)	
Base	0.735 (0.690, 0.780)	0.044 (0.004)		
No. of diagnoses	0.753 (0.708, 0.797)	0.044 (0.004)	0.018 (2.39)	
No. of drugs	0.763 (0.718, 0.807)	0.043 (0.004)	0.028 (3.75)	
No. of Aggregated Diagnosis Groups™	0.745 (0.701, 0.789)	0.044 (0.004)	0.010 (1.33)	
Resource Utilization Bands	0.749 (0.703, 0.795)	0.043 (0.004)	0.014 (1.86)	
Chronic Disease Score	0.761 (0.717, 0.805)	0.043 (0.004)	0.026 (3.55)	
Charlson Index	0.752 (0.708, 0.797)	0.043 (0.004)	0.017 (2.34)	
Elixhauser Index	0.811 (0.768, 0.853)	0.044 (0.004)	0.017 (2.34)	
Prostate	0.011 (0.700, 0.055)	0.072 (0.007)	5.075 (10.2J)	
Base	0.771 (0.738, 0.804)	0.029 (0.002)		
No. of diagnoses	0.786 (0.755, 0.818)	0.029 (0.002)	0.015 (1.99)	
No. of drugs	0.792 (0.761, 0.822)	0.029 (0.002)	0.020 (2.64)	
No. of Aggregated Diagnosis Groups [™]	0.787 (0.755, 0.818)	0.029 (0.002)	0.016 (2.04)	
Resource Utilization Bands	0.787 (0.755, 0.818)	0.029 (0.002)	0.016 (2.06)	
Chronic Disease Score	0.795 (0.765, 0.825)	0.029 (0.002)	0.024 (3.14)	
Charlson Index	0.779 (0.747, 0.810)	0.029 (0.002)	0.007 (0.97)	
Elixhauser Index Bold values indicate a statistically significant	0.801 (0.770, 0.832)	0.028 (0.002)	0.030 (3.89)	

There were too few AMI events to conduct analyses stratified by cancer site. Therefore, only a single base model was fit to the data (Table 4.15). It resulted in a c-statistic of 0.700, indicating acceptable discriminative performance. The Brier score for this model was very low (0.008) indicating very little prediction error in the base model. The Elixhauser index resulted in the greatest improvement in the c-statistic (6.68%) followed by the Chronic Disease Score (2.99%) and number of different drugs (2.95%).

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The IDI reclassification statistic was statistically significant for all comorbidity measures, with the exception of the number of ADGs[®] (Appendix Table 6.7). The NRI was statistically significant for all comorbidity measures.

Table 4.15: Measures of Discrimination and Prediction Error for Logistic Regression Models Predicting
Incident Acute Myocardial Infarction

1997/98-2011/12	

Models	<i>c</i> -statistic (95% Confidence Interval)	Brier score (Standard Deviation)	Δ c (%)
All Sites			
Base	0.700 (0.673, 0.728)	0.008 (0.000)	
No. of diagnoses	0.709 (0.681, 0.736)	0.008 (0.000)	0.008 (1.18)
No. of drugs	0.721 (0.695, 0.747)	0.008 (0.000)	0.021 (2.95)
No. of Aggregated Diagnosis Groups™	0.706 (0.679, 0.734)	0.008 (0.000)	0.006 (0.86)
Resource Utilization Bands	0.706 (0.678, 0.733)	0.008 (0.000)	0.005 (0.74)
Chronic Disease Score	0.721 (0.695, 0.747)	0.008 (0.000)	0.021 (2.99)
Charlson Index	0.713 (0.687, 0.740)	0.008 (0.000)	0.013 (1.84)
Elixhauser Index	0.747 (0.721, 0.773)	0.008 (0.000)	0.047 (6.68)

Bold values indicate a statistically significant difference from the base model at α =0.05

Osteoporosis-Related Fracture

For osteoporosis–related fractures, which include all fractures of the hip, wrist, spine, and humerus, there were too few fractures to conduct stratified analyses for all cancer sites. Therefore, base and full models were only fit to the data for the breast, colorectal, and lung cancer sites (Table 4.16). As well, a base model was fit to the data for all sites combined.

The base model had c-statistic values ranging from 0.675 (lung cancer) to 0.754 (breast cancer), indicating poor to acceptable discriminative performance. However, Brier score values were very low, indicating minimal prediction error for the base model. Across all full models the improvements in discriminative performance were small; the percentage increase in the c-statistic was greater than 5% only for the Elixhauser index in the model for lung cancer (5.62%). The Brier score values did not decrease for any of the full models.

The reclassification statistics (Appendix Table 6.8) indicate that for the cancer–specific models, both the IDI and NRI were statistically significant. However, for the full model, the NRI was statistically significant for all comorbidity measures. The IDI was statistically significant for the number of different diagnoses, number of ADGs[®], RUBs, and Elixhauser index.

Table 4.16: Measures of Discrimination and Prediction Error for Logistic Regression Models Predicting Incident Osteoporosis-Related Fractures By cancer site, 1997/98-2011/12

	c -statistic		
Models		Brier score	A = (9/)
widdels	(95% Confidence	(Standard Deviation)	Δ <i>c</i> (%)
_	Interval)		
Breast			
Base	0.754 (0.701, 0.807)	0.010 (0.001)	
No. of diagnoses	0.758 (0.705, 0.810)	0.010 (0.001)	0.004 (0.58)
No. of drugs	0.756 (0.703, 0.809)	0.010 (0.001)	0.003 (0.34)
No. of Aggregated Diagnosis Groups™	0.761 (0.709, 0.814)	0.010 (0.001)	0.008 (1.04)
Resource Utilization Bands	0.756 (0.702, 0.809)	0.010 (0.001)	0.002 (0.28)
Chronic Disease Score	0.754 (0.701, 0.807)	0.010 (0.001)	0.000 (0.06)
Charlson Index	0.755 (0.702, 0.809)	0.010 (0.001)	0.002 (0.23)
Elixhauser Index	0.777 (0.722, 0.831)	0.010 (0.001)	0.023 (3.06)
Colorectal			
Base	0.712 (0.658, 0.766)	0.012 (0.001)	
No. of diagnoses	0.716 (0.663, 0.769)	0.012 (0.001)	0.004 (0.52)
No. of drugs	0.725 (0.671, 0.779)	0.012 (0.001)	0.013 (1.82)
No. of Aggregated Diagnosis Groups [™]	0.721 (0.668, 0.774)	0.012 (0.001)	0.009 (1.27)
Resource Utilization Bands	0.722 (0.669, 0.774)	0.012 (0.001)	0.010 (1.39)
Chronic Disease Score	0.720 (0.667, 0.773)	0.012 (0.001)	0.008 (1.12)
Charlson Index	0.712 (0.658, 0.766)	0.012 (0.001)	0.000 (-0.04)
Elixhauser Index	0.731 (0.680, 0.783)	0.012 (0.001)	0.019 (2.73)
Lung	· · · · · ·		
Base	0.675 (0.626, 0.725)	0.014 (0.001)	
No. of diagnoses	0.676 (0.627, 0.726)	0.014 (0.001)	0.001 (0.16)
No. of drugs	0.676 (0.628, 0.725)	0.014 (0.001)	0.001 (0.15)
No. of Aggregated Diagnosis Groups™	0.676 (0.627, 0.726)	0.014 (0.001)	0.001 (0.16)
Resource Utilization Bands	0.676 (0.627, 0.725)	0.014 (0.001)	0.001 (0.08)
Chronic Disease Score	0.681 (0.632, 0.729)	0.014 (0.001)	0.005 (0.78)
Charlson Index	0.676 (0.627, 0.725)	0.014 (0.001)	0.000 (0.05)
Elixhauser Index	0.713 (0.664, 0.762)	0.014 (0.001)	0.038 (5.62)
All Sites			
Base	0.682 (0.655, 0.709)	0.011 (0.001)	
No. of diagnoses	0.695 (0.668, 0.722)	0.011 (0.001)	0.013 (1.86)
No. of drugs	0.693 (0.666, 0.720)	0.011 (0.001)	0.011 (1.58)
No. of Aggregated Diagnosis Groups™	0.697 (0.670, 0.724)	0.011 (0.001)	0.015 (2.23)
Resource Utilization Bands	0.695 (0.668, 0.722)	0.011 (0.001)	0.013 (1.85)
Chronic Disease Score	0.693 (0.666, 0.720)	0.011 (0.001)	0.011 (1.59)
Charlson Index	0.686 (0.659, 0.713)	0.011 (0.001)	0.004 (0.54)
Elixhauser Index	0.705 (0.678, 0.733)	0.011 (0.001)	0.023 (3.43)
Bold values indicate a statistically significant			

Bold values indicate a statistically significant difference from the base model at α =0.05

This demonstration project about the predictive validity of general–purpose comorbidity measures for individuals with a cancer diagnosis was a methodological study to provide recommendations about the optimal comorbidity measure(s) to include in observational studies for individuals with a cancer diagnosis. Adjusting for the confounding effects of comorbidity is essential to produce unbiased estimates of the association between exposure (i.e., cancer diagnosis) and outcome (e.g., measures of healthcare use or presence of health outcomes like hypertension or diabetes). Our extensive analyses across different cancer sites and outcome measures revealed that the optimal measure varies with the outcome of interest and the cancer site under investigation.

TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER CREATOR EXP

The Elixhauser index performed best for one-year all-cause mortality, one-year in-hospital mortality, one-year hospitalization, incident diabetes diagnosis, acute myocardial infarction diagnosis, and congestive heart failure diagnosis outcomes. For hypertension diagnosis, the Elixhauser index had similar predictive validity to the Chronic Disease Score and a measure of the number of different drugs prescribed in the year prior to cancer diagnosis. For healthcare use rates, the number of ADGs[®], number of different drugs, and number of diagnoses performed better than the Elixhauser index in terms of predictive validity. At the same time, the incremental improvement in predictive performance was not always high and the reclassification statistics used to assess incremental predictive performance in the logistic regression models, while statistically significant, were never large. The base model, which included patient demographic and stage information (where available), resulted in acceptable predictive performance for several of the cancer sites and outcomes.

Overall, we recommend the Elixhauser index for measuring comorbidity in individuals with a cancer diagnosis. However, we also recognize that one disadvantage of the Elixhauser index is that it is entered into a prediction model as a series of binary diagnosis variables, which can result in model overfitting if the number of outcome events is small relative to the number of model predictors. Recently, a single composite Elixhauser score (van Walraven et al., 2009) has been proposed. This development helps to overcome this limitation of using the Elixhauser score in risk prediction models for individuals with a cancer diagnosis.

CHAPTER 5: CONCLUSIONS AND RECOMMENDATIONS

This study examined the characteristics of the Manitoba Cancer Registry as it was integrated into the Repository housed at Manitoba Centre for Health Policy (MCHP). The Registry contains all incident cases of cancer in Manitoba; the data provided to MCHP covers the period from 1984 onward. These data are used for provincial, national, and international cancer surveillance and cancer control activities. Previous studies have linked the Manitoba Cancer Registry to administrative health data in Manitoba, including hospital discharge abstract, physician billing claims, and prescription drug records, to conduct population–based studies about health and healthcare use. However, by incorporating these data into the Repository, a broader range of studies are possible, focusing on such topics as the determinants of health, comparative effectiveness of cancer treatments, and quality of care for cancer patients.

A standardized data quality assessment was conducted as a first step in integrating the Manitoba Cancer Registry into the Repository. This assessment is undertaken for all administrative data contained in the Repository.

Comparisons with some existing administrative data in the Repository were used to investigate the optimal data source for measuring residence location of cancer patients. As well, using the Manitoba Cancer Registry data as the reference standard, we examined the validity of diagnoses recorded in hospital records and physician billing claims for ascertaining cancer cases. This investigation was done to assess whether hospital records and physician claims are valid administrative data sources for ascertaining selected types of cancer.

Finally, two demonstration projects were conducted to explore the potential uses of the data for population health and health services research. One policy–oriented demonstration project examined the use of EDs by cancer patients and the second demonstration project, which was a methodological study, investigated the predictive validity of general–purpose comorbidity measures for individuals with a cancer diagnosis on a number of different health and healthcare outcomes.

Key Findings

The MCHP Data Quality Framework was applied to the Manitoba Cancer Registry data to ensure that researchers who use the Repository have access to standardized information about the Manitoba Cancer Registry data fields. This standardized assessment, which is routinely applied to all administrative data in the Repository, provides summary information about valid, invalid, missing, and outlier observations, assesses linkage capabilities, and examines trends in key fields to assess internal consistency. The MCHP Data Quality Framework contains similar measures of quality to those found in existing frameworks for evaluating the quality of cancer registry data (Canadian Surveillance and Epidemiology Networks, 2009; Parkin & Bray, 2009). These frameworks emphasize the importance of completeness, accuracy, timeliness, and comparability of cancer registry data for surveillance and cancer control activities. The application of the MCHP Data Quality Framework to the Manitoba Cancer Registry data confirms the high quality of these data, based on internal assessments, and their excellent linkage capabilities with other administrative data.

The MCHP Data Quality Framework is not intended to provide a comprehensive picture of data quality, in part because it does not rely on external data sources to evaluate the quality of the data; chart review studies or other clinical data sources are needed to investigate the external validity of information about the patient and the tumour. The MCHP Data Quality Framework does, however, provide a starting point to evaluate some essential data quality features.

One key finding of the data quality evaluation of the Manitoba Cancer Registry data is the lack of cancer stage information prior to 2004. At the same time, the Manitoba Cancer Registry is one of the few cancer registries that contains stage information. Cancer stage is a critical piece of information for developing prognostic (i.e., predictive)

models, such as for survival prediction (Yao-Lung, Dar-Ren, & Tsai-Wang, 2012); stage information can also be used to assess the appropriateness of cancer treatment(s). A second limitation of the Manitoba Cancer Registry data is the small gap in treatment date information in 2005. At the same time, many cancer registries do not contain treatment information, particularly detailed information about the characteristics of surgical interventions (Hernandez et al., 2013).

Another key finding from this research was the high concordance between place of residence at cancer diagnosis and place of residence as recorded in hospital records and the population registry. This agreement was important because it confirms any of these location variables could subsequently be used in analyses of geographic variation studies. However, the limitation is that none of the data contain information on place of residence at birth, which could be used in cancer research and surveillance investigations focusing on early life environmental exposures. At the same time, change in location of residence in the population registry has been used to examine residential mobility of chronic disease population, a potentially important indicator of continuity of care (Lix et al., 2006).

In addition, we found that for breast, prostate, lung, and colorectal cancers, diagnosis codes in hospital records and physician billing claims exhibited a high degree of validity when compared to the Manitoba Cancer Registry data. This suggests that for years in which Manitoba Cancer Registry data are not available in the Repository, it may be feasible to use these administrative data to ascertain incident cancer cases.

While the demonstration projects produced specific findings regarding use of ED services and optimal measures of comorbidity in individuals with a cancer diagnosis, their main function was to enable teams of MCHP and CancerCare Manitoba scientists, analysts, and technical staff to collaborate. Useful insights were gained into the complexities of data quality, study design, choice of measures to include in statistical models, and analysis techniques. These collaborations will benefit future policy–relevant and methodological investigations involving linked cancer registry and administrative data.

Conclusions

Linkage of Manitoba Cancer Registry data to other administrative data in the MCHP Research Data Repository creates multiple opportunities to conduct cancer–related population health and health services research. While cancer registries contain information about cancer diagnosis, stage, and treatment, linkage with other data enables longitudinal investigations of cancer patient patterns of care and health outcomes. As well, data linkage benefits detailed investigations of specific sub–groups within the population, such as residents of long–term care facilities and ethnocultural groups, including First Nations and Métis populations. Palliative and end–of–life care patterns and outcomes can be investigated. As well, economic investigations of the total lifetime costs of care and of different care patterns can be conducted.

Linkage of Manitoba Cancer Registry data with other administrative data, such as hospital records and physician billing claims, can be used to examine the accuracy and completeness of treatment information. Finally, the impact of population–based interventions, such as risk prevention programs, can be explored. Overall, linking administrative and cancer registry data can overcome the limitations of using either type of data source on its own (MacDonald, Alaghehbandan, Knight, Rose, & Collins, 2013).

Recommendations

The following recommendations arise from this research:

Recommendation #1: Ensure that research teams using Manitoba Cancer Registry data have access to expertise from both CancerCare Manitoba and MCHP.

This research benefitted substantially from the combined expertise of program staff, analysts and researchers at CancerCare Manitoba and MCHP. CancerCare Manitoba staff provided important knowledge about changes in data collection protocols over time, data quality evaluation methods, and expertise in the interpretation of the contents of specific fields within the Manitoba Cancer Registry. Ensuring that the knowledge from CancerCare Manitoba is captured within the MCHP Concept Dictionary will ensure that it is available to all investigators who use the Manitoba Cancer Registry in their own research.

Recommendation #2: Develop concepts on cancer-related project-specific data quality for the MCHP Concept Dictionary.

The results of the location of residence agreement analysis and diagnostic validity analysis can be incorporated into the MCHP Concept Dictionary, an on-line tool that describes over 200 research concepts developed at MCHP for analyzing data contained in the Repository. These detailed operational definitions of variables or measures used in MCHP research include a discussion of the issue(s) involved, approaches used, programming tips/cautions, SAS code, additional readings, and references.

There are other data quality investigations that could be undertaken, particularly those focused on the accuracy and completeness of cancer treatment information in the Manitoba Cancer Registry (Lix et al., 2012a). A 2013 study found high concordance between treatment information in the registry and chart review amongst non–small cell lung cancer patients (Klein-Geltink et al., 2013). Assessments could be conducted for other years of data and for other types of cancer. However, for almost one–third of patients in the chart review, the reason for non–referral to an oncologist for treatment was either missing or unclear. This was identified as an area for further performance evaluation and quality improvement.

Recommendation #3: Add additional CancerCare Manitoba data to strengthen cancer-related research in Manitoba.

Work is currently underway to facilitate the inclusion of cancer screening data into the Repository housed at MCHP. In addition, any program data that are available within the province could be added to the Repository to facilitate population program evaluations (Porter et al., 2012). The inclusion of new sources of data would benefit cancer researchers in Manitoba.

In the first demonstration project we found that increased use of emergency departments after diagnosis was associated with an increased risk of death after controlling for cancer stage, demographics and other healthcare use. However, without other adjustments, ED use prior to cancer diagnosis was associated with a higher risk of death. Further analysis indicated that later stage cancer patients more frequently used the ED prior to diagnosis. The addition of screening data could add to our understanding of these associations by indicating if individuals screened for cancer are less likely to be diagnosed at later stages and also less likely to use the ED prior to diagnosis.

Recommendation #4: Undertake deliverables and research projects that capitalize on the strengths of the Manitoba Cancer Registry data.

The Ontario Cancer Data Linkage Project, which involved the linkage of Ontario Cancer Registry data to other administrative health data and release to individual investigators has facilitated many studies, including those about:

"variation in the surgical management of renal tumours; healthcare settings, transitions and services used by cancer patients in the last year of life; the effect of adjuvant hormonal treatment on bone health in older breast cancer survivors; the impact of adherence to HER2 testing, treatment and monitoring guidelines in early–stage breast cancer; phase–specific and lifetime costs of cancer in Ontario; and the epidemiology and burden of illness associated with hepatocellular carcinoma" (Earle, 2014).

A diverse range of projects could also be conducted in Manitoba using the linked Manitoba Cancer Registry data. For example, more detailed investigations about the use of primary care amongst cancer patients can be undertaken using electronic medical record (EMR) data from the Canadian Primary Care Sentinel Surveillance Network that has recently been acquired into the Repository (Birtwhistle, Godwin, Leggett, & Martin, 2015). Policy–relevant research aligned with the "Choosing Wisely" campaign can be undertaken (Choosing Wisely Canada (CWC), 2015). Recommendations relevant to cancer screening and healthcare interventions for cancer patients could be explored using linked Manitoba Cancer Registry and administrative data. One recommendation is to avoid annual routine colonoscopy surveillance in patients following colon cancer surgery; the extent of adherence to this recommendation could be examined using linked data.

These data could also facilitate micro–simulation studies to examine such topics as the potential impact of new population–based screening programs on healthcare use (Porter et al., 2012; Rutter & Savarino, 2010) amongst individuals with a cancer diagnosis. This is one of the objectives of a Nova Scotia program of research for colorectal cancer that has linked cancer registry data with administrative health data. Simulation models can be used to explore a variety of "what–if" scenarios about the effect of changes in risk factor prevalence on cancer incidence, costs of care, and healthcare outcomes.

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APPENDIX 1: TECHNICAL DEFINITIONS OF INDICATORS AND MEASURES USED IN THIS REPORT

Acute Myocardial Infarction (AMI)

The probability of hospitalization or death due to AMI for each cancer patient up to one year after cancer diagnosis was estimated in a logistic regression model with all cancer sites combined (breast, bladder, colorectal, CLL, lung, prostate). Incident AMIs were identified by either: i) an inpatient hospitalization with the most responsible diagnosis of AMI and a length of stay of three or more days (unless the patient died in hospital); or ii) a death with AMI listed as the primary cause of death on the Vital Statistics death record. Diagnosis codes for AMI include ICD–9–CM code 410 and ICD–10–CA code I21. Hospitalizations for less than three days were excluded as likely "rule out" AMI cases; transfers between hospitals were tracked to ensure all "true" AMI cases staying at least three days in hospital(s) were counted. A one–year washout period was used to identify incident AMIs after cancer diagnosis. The base model included age at cancer diagnosis, sex, health region at time of cancer diagnosis, income quintile (urban and rural combined) and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy and/or surgical intervention (not all treatments were applicable to all sites). Additional models were fit to the data including each comorbidity measure separately, as well as all covariates in the base model. These regression models included cancer cases diagnosed from April 1, 1997 to December 31, 2011 and were limited to cancer patients age 18 and older who were continuously covered by Manitoba Health Insurance in the year prior to their cancer diagnosis.

Aggregated Diagnosis Group™ (ADG®)

ADGs[®] are a part of the Johns Hopkins Adjusted Clinical Group (ACG[®]) case–mix system. Cancer patients were assigned up to 32 ADGs[®] based on their diagnoses from hospitalizations and physician visits in the year prior to their cancer diagnosis. Individuals can be assigned multiple ADGs[®] if they have more than one disease or illness, but similar illnesses would be assigned to the same ADG[®]. Every ICD–9–CM and ICD–10–CA diagnosis code assigned to a patient is grouped into one of 32 different ADGs[®] based on five clinical and expected utilization criteria: 1) duration of the condition (acute, recurrent, or chronic); 2) severity of the condition (e.g., minor and stable versus major and unstable); 3) diagnostic certainty (symptoms focusing on diagnostic evaluation versus documented disease focusing on treatment services); 4) etiology of the condition (infectious, injury, or other); and 5) specialty care involvement (medical, surgical, obstetric, haematology, etc.). For the purposes of this research, the number of ADGs[®] was summed, and the resulting value (ranging from 0–32) was treated as a continuous comorbidity measure. For generalizability, cancer diagnoses were included in the ACG[®] grouper when comparing comorbidity measures.

All–Cause Mortality

The probability of dying in the year after cancer diagnosis was estimated in a logistic regression model stratified by cancer site (breast, bladder, colorectal, CLL, lung, prostate). Date of death was obtained from the Manitoba Health Insurance Registry. The base model included age at cancer diagnosis, sex, health region at time of cancer diagnosis, income quintile (urban and rural combined) and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy, and/or surgical intervention (not all treatments were applicable to all sites). Additional models were run including each comorbidity measure separately as well as all covariates in the base model. These regression models included cancer cases diagnosed from April 1, 1997 to December 31, 2011, and were limited to cancer patients age 18 and older who were continuously covered by Manitoba Health Insurance in the year prior to their cancer diagnosis.

Ambulatory Visit Rate

Ambulatory visits include almost all contacts with physicians (general practitioners, family physicians, and specialists): office visits, walk–in clinics, home visits, personal care home (nursing home) visits, and visits to outpatient departments. Excluded are services provided to patients while admitted to hospital and emergency department visits. Visits for prenatal care are now included due to improved coding practices. Ambulatory visit

rates were included in this project in multiple ways: i) the number of ambulatory visits per person per month were a covariate in generalized linear models estimating monthly ED use in Chapter 3 (see Emergency Department Visit Rate for more information); ii) the number of ambulatory visits were included in Cox proportional hazards regression models as a baseline covariate counting the number of visits in the year prior to index date, as well as a time–varying covariate counting the number of visits at every six month interval or portion thereof in the follow–up period in Chapter 3 (see Survival Analysis for more information); and iii) the number of ambulatory visits for each cancer patient up to one year after cancer diagnosis per person–year was modelled in a negative binomial regression model stratified by cancer site (breast, bladder, colorectal, CLL, lung, prostate) in Chapter 4. The base model included age at cancer diagnosis, sex, health region at time of cancer diagnosis, income quintile (urban and rural combined) and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy, and/or surgical intervention (not all treatments were applicable to all sites). Additional models were run including each comorbidity measure separately as well as all covariates in the base model. These regression models included cancer cases diagnosed from April 1, 1997 to December 31, 2011 and were limited to cancer patients age 18 and older who were continuously covered by Manitoba Health Insurance in the year prior to their cancer diagnosis.

Anatomical Therapeutic Chemical (ATC) Classification

ATC codes are a widely used drug classification system, derived from the World Health Organization's Collaborating Centre for Drug Statistics Methodology. The drugs are divided into different groups at five levels according to the organ or system on which they act and/or therapeutic and chemical characteristics: 1) anatomical group; 2) therapeutic main group; 3) therapeutic/pharmacological subgroup; 4) chemical/therapeutic/pharmacological subgroup; and 5) subgroup for chemical substance.

Cancer Diagnosis Agreement

Patients' cancer diagnoses provided in the cancer registry were validated based on cancer diagnosis information in the hospital abstract and physician claims data. Validating diagnoses in the cancer registry is based on the following:

- cancer diagnoses in 1+ inpatient hospitalization or 1+ physician claims data within one month before and one month after the date of diagnosis in the cancer registry
- cancer diagnoses in 1+ inpatient hospitalization or 1+ physician claims data within six months before and six months after the date of diagnosis in the cancer registry
- cancer diagnoses in 1+ inpatient hospitalization or 1+ physician claims data within one year before and one year after the date of diagnosis in the cancer registry

The cohort of patients included in this validation included patients diagnosed with cancer after April 1, 1997. Only patients with the following primary cancer sites were included: bladder, breast, colorectal, lung and prostate.

Cancer site was identified using the following diagnosis codes in the cancer registry, hospital abstracts, and physician claims data:

Cancer Site	ICD-0-3	ICD-9-CM	ICD-10-CA
Bladder	C670–C679	188	C67
Breast	C500–C509	174	C50
Colorectal (colon, rectum and rectosigmoid)	C180–C189, C199, C209, C260	153, 1540, 1541	C18, C19, C20
Lung and bronchus	C340–C349	162	C34
Prostate	C619	185	C61

Degree of agreement between diagnoses in these data was measured using kappa, sensitivity, specificity, positive predictive value, and negative predictive value statistics. Note that except for the confidence interval for the kappa statistic, which is based on asymptotic confidence interval, all confidence intervals are based on the Wilson score interval.

Cancer Site

Cancer site indicates the part of the body where the cancer originated, i.e., the primary site, regardless of metastasis. The following cancer sites were focused on in this study, as defined by International Classification of Diseases for Oncology, 3rd Edition (ICD–O–3) codes:

Cancer Site	ICD-O-3 Topography Axis	ICD-O-3 Morphology Axis
Bladder	C670–C679	excluding 9590–9989
Breast	C500–C509	excluding 9590–9989
Chronic lymphocytic leukemia (CLL)	C420, C421, C424,	9823/3 only
Colorectal (colon, rectum and rectosigmoid)	C180–C189, C199, C209, C260	excluding 9590–9989
Lung and bronchus	C340–C349	excluding 9590–9989
Prostate	C619	excluding 9590–9989

Cancer Stage

Summary cancer stage indicates the severity of an individual's cancer at time of diagnosis and takes into account tumour stage (size of primary tumour and extent of tumour(s)), node stage (whether cancer has spread to adjacent lymph nodes), and metastasis (whether the cancer has spread from the primary site to other parts of the body). Staging follows the guidelines of the American Joint Committee on Cancer (AJCC). Cancer stage is available from January 1, 2004 onwards and is coded using AJCC 6th Edition from 2004–2009 and AJCC 7th Edition from 2010 onwards. For the purposes of this research, cancer stage has been collapsed into summary cancer stage: stage I (least severe) to stage IV (most severe) and unknown stage. Summary cancer stage was used as a covariate in regression models to control for severity of cancer.

Charlson Index

The Charlson Comorbidity Index is a method for categorizing comorbidities based on all the ICD-9-CM and ICD-10-CA diagnosis codes attributed to cancer patients during medical visits and hospitalizations in the year prior to their cancer diagnosis. Post-admit comorbidities from the hospital abstract data were excluded, based on diagnosis type (C or 2). Due to the coding of only the first three digits of the ICD-9-CM diagnosis code in medical claims data, some diagnosis codes did not have the required specificity to correctly identify the comorbidities in the table below. Therefore, some modifications were required for diagnoses from medical claims only: i) many diagnosis codes were truncated or excluded as specified in the table below; ii) it was not possible to differentiate between the comorbidity measures "Diabetes with Chronic Complications" and "Diabetes without Chronic Complications." Thus, any diagnosis code for diabetes from medical claims was categorized into the latter. Each of the 17 comorbidity categories have an associated weight, based on the adjusted risk of one-year mortality; the sum of in the weighted scores for each comorbid conditions produces a single comorbidity score for each cancer patient. A score of zero indicates that indicates that the individual has none of the comorbid conditions that comprise the Charlson index. For generalizability, cancer diagnoses were included in the calculation of the Charlson score when comparing comorbidity measures; however, when matching cancer patients to cancer-free matches to examine ED use, a cancer-free weighted Charlson score was used. The following table lists the comorbid conditions included, and their associated ICD-9-CM and ICD-10-CA diagnosis codes and weights:

Comorbid Condition	ICD-9-CM Diagnosis Codes	ICD-10-CA Diagnosis Codes	Weight
Myocardial Infarction	410, 412	I21, I22, I25.2	1
Congestive Heart Failure	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428 (hosp), 398, 402, 425, 428 (med)		1
Peripheral Vascular Disease	093.0, 437.3, 440, 441, 443.1–443.9, 447.1, 557.1, 557.9, V43.3 (hosp) 440, 441, 443, 447, 557 (med)	I70, I71, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9	1
Cerebrovascular Disease	362.34, 430–438 (hosp) 430–438 (med)	G45, G46, H34.0, I60–I69	1
Dementia	290, 294.1, 331.2 (hosp) 290, 294, 331 (med)	F00–F03, F05.1, G30, G31.1	1
Chronic Pulmonary Disease	416.8, 416.9, 490–505, 506.4, 508.1, 508.8 (hosp) 416, 490–496, 500–505 (med)	I27.8, I27.9,J40–J47, J60–J67 J68.4, J70.1, J70.3	1
Connective Tissue Disease- Rheumatic Disease	446.5, 710.0–710.4, 714.0–714.2, 714.8, 725 (hosp) 446, 710, 714, 725 (med)	M05, M06, M31.5, M32–M34, M35.1, M35.3, M36.0	1
Peptic Ulcer Disease	531–534	K25–K28	1
Mild Liver Disease	070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 070.6, 070.9, 570, 571, 573.3, 573.4, 573.8, 573.9, V42.7 (hosp) 070, 570, 571, 573 (med)	B18, K70.0–K70.3, K70.9, K71.3–K71.5, K71.7, K73, K74, K76.0, K76.2–K76.4, K76.8, K76.9, Z94.4	1
Diabetes without Chronic Complications	250.0–250.3, 250.8, 250.9 (hosp) 250 (med)	E10.0, E10.1, E10.6, E10.8, E10.9, E11.0, E11.1, E11.6, E11.8, E11.9, E12.0, E12.1, E12.6, E12.8, E12.9, E13.0, E13.1, E13.6, E13.8, E13.9, E14.0, E14.1, E14.6, E14.8, E14.9	1
Diabetes with Chronic Complications	250.4–250.7 (med n/a)	E10.2–E10.5, E10.7, E11.2–E11.5, E11.7, E12.2–E12.5, E12.7, E13.2–E13.5, E13.7, E14.2–E14.5, E14.7	2
Paraplegia and Hemiplegia	334.1, 342, 343, 344.0–344.6, 344.9 (hosp), 334, 342–344 (med)	G04.1, G11.4, G80.1, G80.2, G81, G82, G83.0–G83.4, G83.9	2
Renal Disease	403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 582, 583.0–583.7, 585, 586, 588.0. V42.0, V45.1, V56 (hosp), 403, 582, 583, 585, 586, 588, V56 (med)	I12.0, I13.1, N03.2–N03.7, N052–N05.7, N18, N19, N25.0, Z49.0–Z49.2, Z94.0, Z99.2	2
Cancer	140–172, 174–195.8, 200–208, 238.6 (hosp), 140–172, 174–195, 200–208, 238 (med)	C00–C26, C30–C34, C37–C41, C43, C45–C58, C60–C76, C81–C85, C88, C90–C97	2
Moderate or Severe Liver Disease	456.0–456.2, 572.2–572.4, 572.8 (hosp), 456, 572 (med)	185.0, 185.9, 186.4, 198.2, K70.4, K71.1, K72.1, K72.9, K76.5–K76.7,	3
Metastatic Carcinoma	196–199	C77–C80	6
HIV/AIDS	042–044	B20–B22, B24	6

Chemotherapy during the course of cancer treatment was determined from the CancerCare Manitoba Cancer Registry. For each primary cancer site, the start date of chemotherapy, if applicable, was noted, as well as the ICD–9–CM or CCI code corresponding to the type of chemotherapy that occurred. For the purposes of this research, all types of chemotherapy were grouped so that each cancer patient would be categorized as having received this treatment or not. The following ICD–9–CM/CCI codes were used to identify chemotherapy in the cancer registry:

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ICD-9-CM Procedure Codes	CCI Codes
	1.ZZ.35.CA-M0 Pharmacotherapy, total body, per orifice (oral) approach, using antineoplastic agent NOS
	1.ZZ.35.CA-M5 Pharmacotherapy, total body, per orifice (oral) approach, using other antineoplastic
	1.ZZ.35.CA-M9 Pharmacotherapy, total body, per orifice (oral) approach, using combination [multiple] antineoplastic agents
	1.ZZ.35.HA-M0 Pharmacotherapy, total body, percutaneous approach [intradermal, intramuscular,
99.25 Injection or	intravenous, subcutaneous], using antineoplastic agent NOS,
infusion of cancer	1.ZZ.35.HA-M5 Pharmacotherapy, total body, percutaneous approach [intradermal, intramuscular,
chemotherapeutic	intravenous, subcutaneous], using other antineoplastic
substance	1.ZZ.35.HA-M9 Pharmacotherapy, total body, percutaneous approach [intradermal, intramuscular,
	intravenous, subcutaneous], using combination [multiple] antineoplastic agents
	1.ZZ.35.YA-M0 Pharmacotherapy, total body, route NEC [transdermal, etc.], using antineoplastic agent NOS
	1.ZZ.35.YA-M5 Pharmacotherapy, total body, route NEC [transdermal, etc.], using other antineoplastic
	1.ZZ.35.YA-M9 Pharmacotherapy, total body, route NEC [transdermal, etc.], using combination
	[multiple] antineoplastic agents

Chronic Disease Score

The chronic disease score is a comorbidity index based on the ATC codes for prescriptions cancer patients filled in the year prior to their cancer diagnosis. Each of the 24 comorbidity categories contain ATC codes for pharmaceutical agents for treatment of different chronic diseases as in the table below (see Anatomical Therapeutic Chemical Classification for more information). Prescriptions for any drug falling into one of the comorbidity categories would be included, and a person could have several prescriptions for drugs with the same comorbidity category, but the comorbidity category would only be counted once in the chronic disease score. All of the comorbidity categories are summed, resulting in single chronic disease score for each cancer patient ranging from 0–24. Nearly all prescriptions dispensed from community-based pharmacies across the province were included; prescriptions drugs given to hospitalized patients and some nursing home residents in personal care homes (PCHs) with hospital-based pharmacies were not included. Prescriptions were limited to those covered by Manitoba Health's Pharmacare Program and prescriptions for over the counter drugs were excluded. These exclusions were made in order to have a common set of drugs that could be compared fairly across the province. For generalizability, prescribed drugs to treat cancer and manage cancer treatment were included in the Chronic Disease Score when comparing comorbidity measures. Note that the Chronic Disease Score comorbidity measure was not included in the series of models predicting the prescription drug rate due to the potential confounding of both predictor and outcome being based on prescription drug data.

Comorbid Condition	ATC Codes
Anxiety & Tension	N05B
Cardiac Disease	C01, C03C, C03EB01
Crohn's & Ulcerative Colitis	A07EC, excluding A07EC01
Coronary & Peripheral Vascular Disease	B01A, C04AD03
Cystic Fibrosis	A09AA02
Depression	N06AA, N06AB, N06AE, N06AF, N06AG, N06AX
Diabetes	A10A, A10B
Epilepsy	N03A, excluding N03AE01
Glaucoma	S01E
Gout	M04A
Hyperlipidemia	C10A
Hypertension	C02, C03A, C03EA01, C07, C08, C09A, C09B
Malignancies	A04AA, L01, excluding L01BA01, L03AA
Pain	N02A
Pain & Inflammation	M01A
Parkinson's Disease	N04B
Peptic Acid Disease	A02A, A02B
Psychotic Illness (including Bipolar Disorders)	N05A
Renal Disease (including End Stage)	B03XA01, V03AE01
Respiratory Illness (including Asthma)	R03
Rheumatologic Conditions	A07EC01, H02, L01BA01, M01CB, M01CC01, P01BA02
Thyroid Disorders	Н03А, Н03В
Transplants	L04AA01, L04AA05, L04AA06, L04AX01
Tuberculosis	J04A

Congestive Heart Failure (CHF)

The probability of being diagnosed with CHF for each cancer patient up to two years after cancer diagnosis was estimated in a logistic regression model stratified by cancer site (breast, bladder, colorectal, CLL, lung, prostate). Incident cases of CHF were identified by either i) an inpatient hospitalization with a diagnosis of CHF; or ii) two or more physician visits with a diagnosis of CHF within the two-year period. Diagnosis codes for CHF include ICD–9–CM code 428 and ICD–10–CA code I50. A two-year washout period was used to identify incident cases after cancer diagnosis, and prevalent cases prior to cancer diagnosis, income quintile (urban and rural combined) and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy and/or surgical intervention (not all treatments were applicable to all sites). Additional models were run including each comorbidity measure separately as well as all covariates in the base model. These regression models included cancer cases diagnosed from April 1, 1997 to December 31, 2011, and were limited to cancer patients age 18 and older who were continuously covered by Manitoba Health Insurance in the two years prior to and the two years following their cancer diagnosis.

Cumulative Number of New Diagnoses

The cumulative number of new diagnoses in hospital discharge abstracts and physician billing claims was measured monthly over the period from two years prior to cancer diagnosis to one year after for cancer patients diagnosed between April 1, 1997 and December 31, 2011. Cancer patients were restricted to those who lived in Manitoba for the entire three–year period and did not die in the one–year period after diagnosis. Post–admit comorbidities from the hospital abstract data were excluded, based on diagnosis type (C or 2). ICD–10–CA diagnosis codes were converted to ICD–9–CM codes, and then all codes were truncated to the third digit. Each

unique ICD–9–CM code was counted on the first instance only over the three–year period to calculate the summation, and total number of diagnoses from previous months was carried over to the next month to create a cumulative count. The mean cumulative number of new diagnoses per month for the cohort of cancer patients is presented in Chapter 4. As a sensitivity analysis, the cumulative count of new diagnoses excluding cancer diagnoses is presented in Appendix 5.

Cumulative Number of New Prescription Drugs

The cumulative number of new prescription drugs prescribed was measured monthly over the period from two years prior to cancer diagnosis to one year after for cancer patients diagnosed between April 1, 1997 and December 31, 2011. Cancer patients were restricted to those who lived in Manitoba for the entire three-year period and did not die in the one-year period after diagnosis. Prescription drugs were categorized by ATC codes and each pharmaceutical agent that falls under a different fourth-level ATC class was counted as a new drug (see Anatomical Therapeutic Chemical Classification for more information). A person could have several prescriptions for drugs in the same fourth-level ATC class, but the drug type would only be counted once in the cumulative count. Each new prescription drug was counted on the first instance only over the three-year period to calculate the summation, and total number of prescription drugs from previous months was carried over to the next month to create a cumulative count. The mean cumulative number of new prescription drugs per month for the cohort of cancer patients is presented in Chapter 4. As a sensitivity analysis, the cumulative count of new prescription drugs to treat cancer and manage cancer treatment is presented in Appendix 5.

Diabetes

The probability of being diagnosed with diabetes for each cancer patient up to two years after cancer diagnosis was estimated in a logistic regression model stratified by cancer site (breast, bladder, colorectal, CLL, lung, prostate). Incident cases of diabetes were identified by either i) an inpatient hospitalization with a diagnosis of diabetes; or ii) two or more physician visits with a diagnosis of diabetes within the two–year period. Diagnosis codes for diabetes include ICD–9–CM code 250 and ICD–10–CA codes E10–E14. A two–year washout period was used to identify incident cases after cancer diagnosis, and prevalent cases prior to cancer diagnosis, income quintile (urban and rural combined), and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy, and/or surgical intervention (not all treatments were applicable to all sites). Additional models were run including each comorbidity measure separately as well as all covariates in the base model. These regression models included cancer diagnosis. This measure of diabetes combines type 1 and type 2 diabetes, as physician claims data do not allow separate identification. Gestational diabetes has a separate diagnosis code and is not specifically included here, but some cases may be included if gestational diabetes was not properly coded.

Elixhauser Index

The Elixhauser index is a method of categorizing comorbidities based on all the ICD–9–CM and ICD–10–CA diagnosis codes attributed to cancer patients during medical visits and hospitalizations in the year prior to their cancer diagnosis. Post–admit comorbidities from the hospital abstract data were excluded, based on diagnosis type (C or 2). Due to the coding of only the first three digits of the ICD–9–CM diagnosis code in medical claims data, some diagnosis codes did not have the required specificity to correctly identify the comorbidities in the table below. Therefore, some modifications were required for diagnoses from medical claims only: i) many diagnosis codes were truncated or excluded as specified in the table below; ii) it was not possible to differentiate between the comorbidity measures "Diabetes with Complications" and "Diabetes without Complications." Thus, any diagnosis code for diabetes from medical claims was categorized into the latter; iii) it was not possible to differentiate between these types of anemia from medical claims was categorized into the latter; iv) it was not possible to determine

whether or not diagnosis codes for peptic ulcer disease included hemorrhage or perforation, so all diagnosis codes for peptic ulcer disease were included in the "Peptic Ulcer Disease excluding bleeding" comorbidity measure. The 31 comorbidity categories are all dichotomous; they are either present or not. For generalizability, cancer diagnoses were included in the calculation of the Elixhauser Comorbidity Measure when comparing comorbidity measures. The following table lists the comorbid conditions included in the Elixhauser index and their associated ICD–9–CM and ICD–10–CA diagnosis codes.

Comorbid Condition	ICD-9-CM Diagnosis Codes	ICD-10-CA Diagnosis Codes
Congestive Heart Failure	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428 (hosp), 398, 402, 425, 428 (med)	109.9, 111.0, 113.0, 113.2, 125.5, 142.0, 142.5–142.9, 143, 150, P29.0
Cardiac Arrhythmia	426.0, 426.13, 426.7, 426.9, 426.10, 426.12, 427.0–427.4, 427.6–427.9, 785.0, 996.01, 996.04, V45.0, V53.3 (hosp), 426, 427 (med)	144.1–144.3, 145.6, 145.9, 147–149, R00.0, R00.1, R00.8, T82.1, Z45.0, Z95.0
Valvular Disease	093.2, 394–397, 424, 746.3–746.6, V42.2, V43.3 (hosp), 394–397, 424, 746 (med)	A52.0, I05–I08, I09.1, I09.8, I34–I39, Q23.0–Q23.3, Z95.2–Z95.4
Pulmonary Circulation Disorders	415.0, 415.1, 416, 417.0, 417.8, 417.9 (hosp), 415, 416, 417 (med)	126, 127, 128.0, 128.8, 128.9
Peripheral Vascular Disorders	093.0, 437.3, 440, 441, 443.1–443.9, 447.1, 557.1, 557.9, V43.3 (hosp), 440, 441, 443, 447, 557 (med)	170, 171, 173.1, 173.8, 173.9, 177.1, 179.0, 179.2, K55.1, K55.8, K55.9, Z95.8, Z95.9
Hypertension without Complications	401	I10
Hypertension with Complications	402–405	I11–I13, I15
Paralysis	334.1, 342, 343, 344.0–344.6, 344.9 (hosp), 334, 342–344 (med)	G04.1, G11.4, G80.1, G80.2, G81, G82, G83.0–G83.4, G83.9
Other Neurological Disorders	331.9, 332.0, 332.1, 333.4, 333.5, 333.92, 334, 335, 336.2, 340, 341, 345, 348.1, 348.3, 780.3, 784.3 (hosp), 331–336, 340, 341, 345, 348 (med)	G10–G13, G20–G22, G25.4, G25.5, G31.2, G31.8, G31.9, G32, G35–G37, G40, G41, G93.1, G93.4, R47.0, R56
Chronic Pulmonary Disease	416.8, 416.9, 490–505, 506.4, 508.1, 508.8 (hosp), 416, 490–496, 500–505 (med)	I27.8, I27.9, J40–J47, J60–J67, J68.4, J70.1, J70.3
Diabetes without Complications	250.0–250.3 (hosp), 250 (med)	E10.0, E10.1, E10.9, E11.0, E11.1, E11.9, E12.0, E12.1, E12.9, E13.0, E13.1, E13.9, E14.0, E14.1, E14.9
Diabetes with Complications	250.4–250.9, (med n/a)	E10.2–E10.8, E11.2–E11.8, E12.2–E12.8, E13.2–E13.8, E14.2–E14.8
Hypothyroidism	240.9, 243, 244, 246.1, 246.8 (hosp), 240, 243, 244, 246 (med)	E00–E03, E89.0
Renal Failure	403.01, 403.11, 403.91, 404.02, 404.03, 404.12, 404.13, 404.92, 404.93, 585, 586, 588.0, V42.0, V45.1, V56 (hosp), 403, 585, 586, 588, V56 (med)	112.0, 113.1, N18, N19, N25.0, Z49.0–Z49.2, Z94.0, Z99.2
Liver Disease	070.22, 070.23, 070.32, 070.33, 070.44, 070.54, 070.6, 070.9, 456.0–456.2, 570, 571, 572.2–572.8, 573.3, 573.4, 573.8, 573.9, V42.7 (hosp), 070, 456, 570–573 (med)	B18, I85, I86.4, I98.2, K70, K71.1, K71.3–K71.5, K71.7, K72–K74, K76.0, K76.2–K76.9, Z94.4
Peptic Ulcer Disease excluding Bleeding	531.7, 531.9, 532.7, 532.9, 533.7, 533.9, 534.7, 534.9 (hosp), 531–534 (med)	K25.7, K25.9, K26.7, K26.9, K27.7, K27.9, K28.7, K28.9
HIV/AIDS	042–044	B20–B22, B24
Lymphoma	200–202, 203.0, 238.6 (hosp), 200–203 (med)	C81–C85, C88, C96, C90.0, C90.2
Metastatic Cancer	196–199	C77–C80
Solid Tumor without Metastasis	140-172, 174-195	C00-C26, C30-C34, C37-C41, C43, C45-C58, C60- C76, C97
Rheumatoid Arthritis/Collagen	446, 701.0, 710.0–710.4, 710.8, 710.9, 711.2, 714, 719.3, 720, 725, 728.5, 728.89, 729.30 (hosp), 446, 701, 710, 711, 714, 719, 720, 725, 728 (med)	L94.0, L94.1, L94.3, M05, M06, M08, M12.0, M12.3, M30, M31.0–M31.3, M32–M35, M45, M46.1, M46.8, M46.9
Coagulopathy	286, 287.1, 287.3-287.5 (hosp), 286, 287 (med)	D65–D68, D69.1, D69.3–D69.6
Obesity	278.0 (hosp), 278 (med)	E66
Weight Loss	260, 261, 262, 263, 7832, 7994 (hosp), 260–263 (med)	E40–E46, R63.4, R64
Fluid and Electrolyte Disorders	2536, 276 (hosp), 276 (med)	E22.2, E86, E87
Blood Loss Anemia	280.0 (hosp), (med n/a)	D50.0
Deficiency Anemia	280.1, 280.8, 280.9, 281 (hosp), 280, 281 (med)	D50.8, D50.9, D51–D53
Alcohol Abuse	265.2, 291.1–291.3, 291.5, 291.8, 291.9, 303.0, 303.9, 305.0, 357.5, 425.5, 535.3, 571.0, 571.1–571.3, 980, V11.3 (hosp), 291, 303, 980 (med)	E52, F10, G62.1, I42.6, K29.2, K70.0, K70.3, K70.9, T51, Z50.2, Z71.4, Z72.1
Drug Abuse	292, 304, 305.2–305.9, V65.42 (hosp), 292, 304, 305 (med)	F11 E52, F16, F18, F19, Z71.5, Z72.2
Psychoses	293.8, 295, 296.04, 296.14, 296.44, 296.54, 297, 298 (hosp), 293,	F20, F22–F25, F28, F29, F30.2, F31.2, F31.5
i sy choses	295, 297, 298 (med)	

ED use data includes all visits to emergency departments in hospitals in Winnipeg (Concordia General Hospital, Grace General Hospital, Health Sciences Centre, St. Boniface General Hospital, Seven Oaks General Hospital, Victoria General Hospital), thus all analyses including this data are restricted to Winnipeg residents as of their cancer diagnosis date. ED visit rates were included in multiple ways throughout Chapter 3 of this report: i) crude rates of ED visits by presenting complaint were calculated per 1,000 person-days in the year prior to cancer diagnosis and up to two years after (see Presenting Complaint for more information); ii) crude rates of ED visits by time of visit (office hours and non-office hours) were calculated per 1,000 person-days in the year prior to cancer diagnosis and up to two years after (office hours were defined as Monday to Friday, 8am to 5pm, excluding holidays, and nonoffice hours were defined as Monday to Friday, after 5pm to before 8am, weekends and holidays); iii) the number of ED visits were included in Cox proportional hazards regression models as a baseline covariate counting the number of visits in the year prior to index date, as well as a time-varying covariate counting the number of visits at every six month interval or portion thereof in the follow-up period (see Survival Analysis for more information); and iv) the rate of ED visits per month was estimated in generalized linear models with generalized estimating equations stratified by cancer site (breast, colorectal, lung, prostate) with person-days included as an offset. Cancer cases were matched to cancer-free residents 1:1 on five-year age group, sex and weighted Charlson groupings (0, 1, 2, 3+), and regression models were run for cancer cases only as well as cases and their matches. The cancer diagnosis date for the individuals in the cancer cohort was used as the index date for the assigned individuals in the matched cohort. The Poisson regression models included the following covariates: month from diagnosis, diagnosis period (pre-diagnosis period: one year to one month before diagnosis date, diagnosis period: one month before and after diagnosis, post-diagnosis period: one month after to two years after diagnosis), cohort (cancer case or match), interaction of cohort and diagnosis period, age, sex (all except for prostate cancer), income quintile, weighted Charlson comorbidity score, majority of ambulatory care and other measures of healthcare use, including ambulatory visits, inpatient hospitalizations and prescription dispensations (scaled into groups of ten). Models for cancer cases only also included summary cancer stage and treatment information, i.e., binary indicators of chemotherapy, radiation therapy, hormone therapy (for breast and prostate sites only) and surgical intervention. Measures of healthcare use were included in all models as time-varying covariates; counts of the number of events were made in one month increments for the one-year period prior to and up to two years after the index date. These regression models included cancer cases (and their matches) diagnosed from January 1, 2007 to December 31, 2010, and were limited to cancer patients who lived in Winnipeg on the date of their cancer diagnosis, and were continuously covered by Manitoba Health Insurance in the year prior to their cancer diagnosis. To test for statistically significant differences in crude rates of ED use during office hour and non-office hour time segments between cases and matches at each time period, and between time periods for cases, the relative rate and corresponding Chi-square probability were calculated using unadjusted Poisson regression.

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Hormone Therapy

Hormone therapy during the course of cancer treatment was determined from the CancerCare Manitoba Cancer Registry. For each primary cancer site, the start date of hormone therapy, if applicable, was noted, as well as the ICD–9–CM or CCI code corresponding to the type of hormone therapy that occurred. For the purposes of this research, all types of hormone therapy were grouped so that each cancer patient would be categorized as having received this treatment or not. The following ICD–9–CM/CCI codes were used to identify hormone therapy in the cancer registry:

ICD-9-CM Procedure Codes	CCI Codes
	1.ZZ.35.CA-M6 Pharmacotherapy, total body, per orifice (oral) approach, using endocrine therapy
	1.ZZ.35.HA-M6 Pharmacotherapy, total body, percutaneous approach [intradermal, intramuscular, intravenous, subcutaneous], using endocrine therapy
	1.ZZ.35.YA-M6 Pharmacotherapy, total body, route NEC [transdermal, etc.], using endocrine therapy

Hypertension

The probability of being diagnosed with hypertension for each cancer patient up to two years after cancer diagnosis was estimated in a logistic regression model stratified by cancer site (breast, bladder, colorectal, CLL, lung, prostate). Incident cases of hypertension were identified by either i) an inpatient hospitalization with a diagnosis of hypertension; or ii) two or more physician visits with a diagnosis of hypertension within the two-year period. Diagnosis codes for hypertension include ICD-9-CM code 401-405 and ICD-10-CA codes 110-113, 115. A two-year washout period was used to identify incident cases after cancer diagnosis, and prevalent cases prior to cancer diagnosis, income quintile (urban and rural combined) and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy, and/or surgical intervention (not all treatments were applicable to all sites). Additional models were run including each comorbidity measure separately as well as all covariates in the base model. These regression models included cancer cases diagnosed from April 1, 1997 to December 31, 2011, and were limited to cancer patients who were continuously covered by Manitoba Health Insurance in the two years prior to and the two years following their cancer diagnosis.

In-Hospital Mortality

The probability of dying while hospitalized in the year after cancer diagnosis was estimated in a logistic regression model stratified by cancer site (breast, bladder, colorectal, CLL, lung, prostate). Deaths noted on the hospital abstract were counted. All Manitoba hospitals were included; PCHs, nursing stations and long-term care facilities were excluded (Deer Lodge Centre, Manitoba Adolescent Treatment Centre, Rehabilitation Centre for Children, and Riverview Health Centre). Out-of-province hospitalizations for Manitoba residents were also included. The base model included age at cancer diagnosis, sex, health region at time of cancer diagnosis, income quintile (urban and rural combined), and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy, and/or surgical intervention (not all treatments were applicable to all sites). Additional models were run including each comorbidity measure separately as well as all covariates in the base model. These regression models included cancer cases diagnosed from April 1, 1997 to December 31, 2011, and were limited to cancer patients age 18 and older who were continuously covered by Manitoba Health Insurance in the year prior to their cancer diagnosis.

Income Quintiles

An income quintile divides the population into five income groups (from lowest income to highest income) such that 20% of the population is in each group. The quintiles are based on dissemination area (DA) level average household income values from a public–use census files. Income quintiles are created within two population groups: urban (Winnipeg and Brandon) and rural (other Manitoba areas). Each person within a DA is "attributed" the average household income of the DA, so this is not an individual income but rather an area–level income measure. Individuals whose postal code does not link with a DA, whose DA has a suppressed average household income, or those who live in a DA where 90% or more of the population is institutionalized (i.e., PCH, prison) cannot not be attributed an income quintile and are referred to as "Income Unknown." For the purposes of this research, income quintiles were assigned to cancer patients based on their postal code of residence as of their date of cancer diagnosis. Data from the 1996, 2001, 2006 and 2011 censuses were used; the census year ± two years to

the year of diagnosis was chosen so that the most accurate income quintile was assigned as of date of diagnosis. Income quintiles were included as a matching variable for matched cohorts and as covariates in regression models throughout this report to control for the potential confounding effects of socio–economic status of cancer patients.

Inpatient Hospitalization

In this study, only inpatient hospital separations were included, which are hospitalizations where patients are formally admitted to the hospital for diagnostic, medical, or surgical treatment, and typically stay for one or more days. All Manitoba hospitals were included; PCHs, nursing stations, and long-term care facilities were excluded (Deer Lodge Centre, Manitoba Adolescent Treatment Centre, Rehabilitation Centre for Children, and Riverview Health Centre). Out-of-province hospitalizations for Manitoba residents were also included. Hospitalizations were included in this project in multiple ways: i) the number of hospitalizations per person per month were a covariate in generalized linear models estimating monthly ED use (see Emergency Department Visit Rate for more information) in Chapter 3; ii) the number of hospitalizations were included in Cox proportional hazards regression models as a baseline covariate counting the number of hospital stays in the year prior to index date, as well as a time-varying covariate counting the number of hospital stays at every six-month interval or portion thereof in the follow-up period in Chapter 3 (see Survival Analysis for more information); and iii) the probability of being hospitalized in the year after cancer diagnosis was estimated in a logistic regression model stratified by cancer site (breast, bladder, colorectal, CLL, lung, prostate) in Chapter 4. The base model included age at cancer diagnosis, sex, health region at time of cancer diagnosis, income quintile (urban and rural combined), and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy, and/or surgical intervention (not all treatments were applicable to all sites). Additional models were fit to the data, one for each comorbidity measure; these models included a comorbidity measure in addition to all covariates in the base model. These regression models included cancer cases diagnosed from April 1, 1997 to December 31, 2011, and were limited to cancer patients age 18 and older who were continuously covered by Manitoba Health Insurance in the year prior to and year following their cancer diagnosis.

Majority of Care

Majority of care is a measure of whether individuals receive more than 75% of their ambulatory care from a single clinician (versus two or more other clinicians). For cancer patients who are 18 to 59 years of age at the time of the cancer diagnosis, the clinician must be a general practitioner, but for those 60 years of age and older, the clinician could be either a general practitioner or internal medicine specialist. This measure was based on each cancer patient's ambulatory visits in the year prior to cancer diagnosis and up to two years after diagnosis. In this report, majority of care was used as covariate to control for good or poor quality of care as a potential confounder of monthly emergency department visit use.

Number of Diagnoses

The number of diagnoses is a comorbidity measure based on all the ICD–9–CM and ICD–10–CA diagnosis codes attributed to cancer patients during medical visits and hospitalizations in the year prior to their cancer diagnosis. Post–admit comorbidities from the hospital abstract data were excluded, based on diagnosis type (C or 2). ICD–10–CA diagnosis codes were converted to ICD–9–CM codes, and then all codes were truncated to the third digit. Each unique ICD–9–CM code over the one–year period was counted to calculate the summation. It is presumed that an increased number of diagnoses equates to higher morbidity or sickness lever. For generalizability, cancer diagnoses were included in the summation of diagnoses when comparing comorbidity measures.

Number of Prescription Drugs Dispensed

The number of different types of drugs prescribed is a comorbidity measure based on the ATC codes of prescribed medications for all prescriptions cancer patients filled in the year prior to their cancer diagnosis. Each pharmaceutical agent that falls under a different fourth–level ATC class was counted as a new drug for each cancer patient (see Anatomical Therapeutic Chemical Classification for more information). A person could have several prescriptions for drugs in the same fourth–level ATC class, but the drug type would only be counted once in the

comorbidity index. This essentially separates drugs used for different health problems and avoids double-counting prescriptions for drugs in the same group. Nearly all prescriptions dispensed from community-based pharmacies across the province were included; prescription drugs given to hospitalized patients and some nursing home residents in PCHs with hospital-based pharmacies were not included. Prescriptions were limited to those covered by Manitoba Health's Pharmacare Program and prescriptions for over the counter drugs were excluded. These exclusions were made in order to have a common set of drugs that could be compared fairly across the province. It is presumed that an increased number of prescribed drugs equates to higher morbidity or sickness lever. For generalizability, prescribed drugs to treat cancer and manage cancer treatment were included in the summation of prescription drugs when comparing comorbidity measures. Note that this comorbidity measure was not included in the series of models predicting the prescription drug rate due to the potential confounding of both predictor and outcome based on prescription drug data.

Osteoporosis-Related Fracture Incidence

The probability of having an osteoporosis–related fracture for each cancer patient up to one year after cancer diagnosis was estimated in a logistic regression model stratified by cancer site (breast, colorectal, lung) as well in a model with all sites combined. Fracture sites included hip, humerus, spine, and wrist as defined in the table below. The first fracture after cancer diagnosis was counted. Note that for fractures diagnosed in hospital, the fracture diagnosis had to be the most responsible diagnosis code. The base model included age at cancer diagnosis, sex, health region at cancer diagnosis, income quintile (urban and rural combined), and cancer treatment: chemotherapy, radiation therapy, hormone therapy, and/or surgical intervention (not all treatments were applicable to all sites). Additional models were fit to the data that included each comorbidity measure in addition to all covariates in the base model. These regression models included cancer cases diagnosed from April 1, 1997 to December 31, 2011, and were limited to cancer patients age 40 and older who were continuously covered by Manitoba Health Insurance in the year prior to their cancer diagnosis. Individuals lost to follow–up in the year after their cancer diagnosis were excluded.

Fracture Site	Algorithm	Diagnosis Codes	Washout Period
Hip	1 hospitalization	ICD-9-CM: 820 ICD-10-CA: S72.0-S72.2	Not required
Humerus	1 hospitalization or 2 physician visits within 3 months	ICD-9-CM: 812 ICD-10-CA: S42	6 months prior to cancer diagnosis
Spine	1 hospitalization or 1 physician visit	ICD-9-CM: 805.2-805.5 (hosp), 805 (med)	6 months prior to cancer diagnosis
Wrist	I hospitalization or 2 physician visits	ICD-9-CM: 813 (hosp), 1st dx must be 813, 2nd dx can be 813 or 814 (med) ICD-10-CA: S52	6 months prior to cancer diagnosis

Postal Code Agreement

The patient's postal code provided in the cancer registry was compared to the patient's postal code reported in the MCHP registry and hospital data for the period 1984–2011. Postal codes in the cancer registry and MCHP registry are obtained for the date of cancer diagnosis. Postal codes in the hospital abstract data are obtained within 90 days before and 90 days after the date of cancer diagnosis. Kappa statistics are used to assess the degree of agreement. For patients with multiple cancer sites, only the first diagnosis site is kept in the analysis.

Prescription Rate

Prescription rates included nearly all prescriptions dispensed from community–based pharmacies across the province; prescription drugs given to hospitalized patients and some nursing home residents in PCHs with hospital–based pharmacies were not included. Prescriptions were limited to those covered by Manitoba Health's Pharmacare Program and prescriptions for over the counter drugs were excluded. These exclusions were made in

order to have a common set of drugs that could be compared fairly across the province. Prescription visit rates were included in this project in multiple ways: i) the number of prescriptions per person per month were a covariate in generalized linear models estimating monthly ED use in Chapter 3 (see Emergency Department Visit Rate for more information); ii) the number of prescriptions were included in Cox proportional hazards regression models as a baseline covariate counting the number of prescriptions in the year prior to index date, as well as a time-varying covariate counting the number of prescriptions at every six month interval or portion thereof in the follow-up period in Chapter 3 (see Survival Analysis for more information); and iii) the number of prescriptions dispensed for each cancer patient up to one year after cancer diagnosis per person-year was modelled in a negative binomial regression model stratified by cancer site (breast, bladder, colorectal, CLL, lung, prostate) in Chapter 4. The base model included age at cancer diagnosis, sex, health region at time of cancer diagnosis, income quintile (urban and rural combined), and cancer treatment variables: chemotherapy, radiation therapy, hormone therapy, and/or surgical intervention (not all treatments were applicable to all sites). Additional models were run including each comorbidity measure separately as well as all covariates in the base model. These regression models included cancer patients diagnosed from April 1, 1997 to December 31, 2011, and were limited to cancer patients age 18 years and older who were continuously covered by Manitoba Health Insurance in the year prior to their cancer diagnosis.

Presenting Complaint Categories

Each emergency department (ED) visit record lists the main reason the patient went to the ED; these are known as presenting complaints. Presenting complaints differ from diagnoses in that the patient may initially present with vague symptoms such as chest pain or swelling, and the clinician later determines the formal diagnosis (e.g., acute myocardial infarction, anaphylactic shock) after examination of the patient. This examination might include laboratory tests or diagnostic interventions. The clinician's diagnosis is not listed on the ED visit record. For the purposes of this research, presenting complaints were grouped based on anatomical classification and severity of complaint. Note that for EDIS data, the complaint category was used to categorize ED visits, except when the category was "E-Triage" or "Unknown". In this latter case, the chief complaint, which is more specific, was used. Crude rates of ED visits for the most frequent groups of presenting complaints were calculated per 1,000 person-days. These rates were stratified by cancer site (breast, colorectal, lung, prostate), and were produced for the pre-diagnosis period (one year to one month before diagnosis date), diagnosis period (one month before and after diagnosis), and post-diagnosis period (one month after to two years after diagnosis). As well, individuals with cancer were matched to cancer-free individuals 1:1 on five-year age group, sex, and weighted Charlson index score (0, 1, 2, 3+), and rates of ED visits were calculated for both groups. The cancer diagnosis date for the individuals in the cancer cohort was used as the index date for the individuals in the matched cancer-free cohort. Unadjusted Poisson regression models were used to test for differences in the rates of ED visits between each cancer cohort and the matched cancer-free cohort.

Presenting Complaint Group	ADT/E-Triage Complaint Code	EDIS Complaint Category	EDIS Chief Complaint
General and Non- Specific Head and Neck	Dizziness Falls Fever Nausea and Vomiting Syncope/Presyncope Weakness Ear Complaint (Non Trauma) Headache Nasal Complaint (Non Trauma) Neck Complaint (Non Trauma) Sore Throat/Mouth Pain Sore Throat	Extremity Weakness/ Symptoms of CVA General and Minor General Weakness Minor Complaints Unspecified Syncope/Presyncope ENT (Ears) ENT (Mouth/Throat/ Neck) ENT (Nose) Headache	Dizziness Falls Fever General Weakness Nausea and Vomiting Syncope Weakness Ear Complaint (Non Trauma) Earache Epistaxis Headache Nasal Complaint (Non Trauma) Neck Complaint (Non Trauma) Sore Throat/Mouth Pain
Respiratory Chest and Cardiovascular	Asthma Cough Shortness of Breath Blood Pressure Complaint Cardiac Arrest Cardiac/Respiratory Arrest Chest Complaint (Non Trauma) Palpitations/Irregular Heart Rate	Cough/Congestion Respiratory Shortness of Breath Cardiovascular	Asthma Cough Shortness of Breath Blood Pressure Complaint: Hypotension Blood Pressure Complaint: Hypertension Chest Complaint (Non Trauma) Chest Pain (Cardiac Features) Chest Pain (Non Cardiac Features)
Abdomen and Gastrointestinal	Abdominal Complaint (Non Trauma) Diarrhea GI Bleeding	Abdominal Pain Gastrointestinal	Cardiac/Respiratory Arrest Edema (limb) Palpitations/Irregular Heart Rate Abdominal Complaint (Non Trauma) Diarrhea GI Bleeding Jaundice Rectal Complaint Rectal/Perineal Pain Vomiting Blood

Presenting Complaint Group	ADT/E-Triage Complaint Code	EDIS Complaint Category	EDIS Chief Complaint
Trauma	Abdominal Complaint (Trauma)	Laceration/Puncture	Abdominal Complaint (Trauma)
	Altered LOC (Trauma)	Lower Extremity Injury	Altered LOC (Trauma)
	Back Complaint (Trauma)	Trauma	Back Complaint (Trauma)
	Burns and Scalds	Upper Extremity Injury	Burns and Scalds
	Chest Complaint (Trauma)		Chest Complaint (Trauma)
	Eye Complaint (Trauma)		Eye Complaint (Trauma)
	Ear Complaint (Trauma)		Ear Complaint (Trauma)
	Head Injury		Head Injury
	Lacerations/Abrasions/ Contusions		Lacerations/Abrasions/
	Limb Complaint (Trauma)		Contusions
	Major Trauma		Limb Complaint (Trauma)
	Minor Trauma		Major Trauma
	Nasal Complaint (Trauma)		Minor Trauma
	Near Drowning/Barotrauma		Nasal Complaint (Trauma)
	Neck Complaint (Trauma)		Near Drowning/ Barotrauma
	Pregnancy < 20 weeks (Trauma)		Neck Complaint (Trauma)
	Pregnancy > 20 weeks (Trauma)		Pregnancy < 20 weeks
			(Trauma)
			Pregnancy > 20 weeks
			(Trauma)
Haematology	Blood Disorder Complaint	n/a	Blood Disorders Complaint
Endocrinology	Diabetic Complaint	n/a	Diabetic Complaint
Psychiatric	Mental Health Assessment	Mental Health	Mental Health Assessment
	Social Concerns		Social Concerns
Substance Abuse	Substance Complaint	Substance Misuse	Overdose (Ingestion)
	Toxic Ingestion/		Substance Abuse
	Poisoning/Overdose		Toxic Ingestion/
			Poisoning/Overdose

Appendix Table: Continued

Presenting Complaint Group	ADT/E-Triage Complaint Code	EDIS Complaint Category	EDIS Chief Complaint
Trauma	Abdominal Complaint (Trauma) Altered LOC (Trauma) Back Complaint (Trauma) Burns and Scalds Chest Complaint (Trauma) Eye Complaint (Trauma) Ear Complaint (Trauma) Head Injury Lacerations/Abrasions/ Contusions Limb Complaint (Trauma) Major Trauma Minor Trauma Nasal Complaint (Trauma) Near Drowning/Barotrauma Neck Complaint (Trauma) Pregnancy < 20 weeks (Trauma) Pregnancy > 20 weeks (Trauma)	Laceration/Puncture Lower Extremity Injury Trauma Upper Extremity Injury	Abdominal Complaint (Trauma) Altered LOC (Trauma) Back Complaint (Trauma) Burns and Scalds Chest Complaint (Trauma) Eye Complaint (Trauma) Ear Complaint (Trauma) Head Injury Lacerations/Abrasions/ Contusions Limb Complaint (Trauma) Major Trauma Minor Trauma Nasal Complaint (Trauma) Near Drowning/ Barotrauma Neck Complaint (Trauma) Pregnancy < 20 weeks (Trauma) Pregnancy > 20 weeks (Trauma)
Haematology	Blood Disorder Complaint	n/a	Blood Disorders Complaint
Endocrinology	Diabetic Complaint	n/a	Diabetic Complaint
Psychiatric	Mental Health Assessment Social Concerns	Mental Health	Mental Health Assessment Social Concerns
Substance Abuse	Substance Complaint Toxic Ingestion/ Poisoning/Overdose	Substance Misuse	Overdose (Ingestion) Substance Abuse Toxic Ingestion/ Poisoning/Overdose
Other Complaints	Allergic Reaction Bites and Stings Child Abuse Suspected Community Exposure Dental Complaint Environmental Exposure Feeding Problems Foreign Body Post-operative Complaint Sexual Assault Toxic Exposure Transplant	Concern for Patient's Welfare Environmental Medication Request	Allergic Reaction Bites and Stings Chemical Exposure Dental Complaint/Tooth Ache Dental/Gum Problem Electrical Injury Foreign Body Medical Device Problem Noxious Inhalation Post-operative Complaint Unknown Complaint
Scheduled	Booked Electives/ Patient Requests	Direct Referral for	Booked Electives/ Patient

Appendix Table: Continued

Radiation Therapy

Radiation therapy during the course of cancer treatment was determined from the Manitoba Cancer Registry. For each primary cancer site, the start date of radiation therapy, if applicable, was noted, as well as the ICD–9–CM or CCI code corresponding to the type of radiation therapy that occurred. For the purposes of this research, all types of radiation therapy were grouped so that each cancer patient would be categorized as having received this treatment or not. The following ICD–9–CM/CCI codes were used to identify radiation therapy in the Manitoba Cancer Registry.

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ICD-9-CM Procedure Codes	CCI Codes
92.2–92.29 Therapeutic radiology and nuclear medicine	1.FU.59.CA-V1 Destruction, thyroid gland, using oral approach radioactive pharmaceutical agent [e.g. I 131, radioiodine]
	1.FU.59.HA-V1 Destruction, thyroid gland, using percutaneous (needle) approach and radioactive pharmaceutical agent [e.g. I-131, radioiodine]
	1.OA.59.DA-AW Destruction, liver, endoscopic [abdominal] approach, using radiofrequency
	1.ZZ.35.HA-V1 Pharmacotherapy, total body, percutaneous approach [intradermal, intramuscular, intravenous, subcutaneous], using radioactive pharmaceutical agent
	x.xx.26.^^ Brachytherapy on any section of the body
	x.xx.27.^^ Radiation on any section of the body

Resource Utilization Bands (RUBs)

RUBs are part of the Johns Hopkins Adjusted Clinical Group[®] (ACG[®]) Case Mix System. The RUBs are a simplified ranking system of each person's expected healthcare resource use based on their pattern of morbidity, which was determined by taking into account all the ICD–9–CM and ICD–10–CA diagnosis codes attributed to cancer patients during medical visits and hospitalizations in the year prior to their cancer diagnosis. In most healthcare research, higher resource use is related to higher levels of morbidity, so RUBs can usually be thought of as a measure of overall sickness level. Cancer patients were assigned to one of six RUB categories: 0–No diagnoses, 1–Healthy User, 2–Low, 3–Moderate, 4–High, 5–Very High. For generalizability, cancer diagnoses were included in the ACG[®] grouper when comparing comorbidity measures.

Surgical Intervention

Surgical interventions such as biopsies, destruction, or removal of tissue that occurred during the course of cancer treatment were determined from the Manitoba Cancer Registry. For each primary cancer site, the date of each intervention, if applicable, was noted, as well as the ICD–9–CM or CCI code corresponding to the type of surgery that occurred. For the purposes of this research, if any surgical intervention took place, the cancer patient would be categorized as having received surgery for cancer treatment. The following ICD–9–CM/CCI codes were used to identify any surgical intervention in the cancer registry.

ICD-9-CM Procedure Codes	CCI Codes
Any Intervention in 0.1.xx–86.xx, excluding:	Any Physical/Physiological Therapeutic Intervention in 1.xx.xx.^^, excluding:
34.92 Injection into thoracic cavity	1.xx.00.^^ -1.xx.58.^^
38.00 Incision of vessel at unspecified site	
38.99 Other puncture of vein	1.xx.70.^^ -1.xx.86.^^
57.33 Closed [transurethral] biopsy of bladder	
85.12 Open biopsy of breast	1.FU.59.HA-V1 Destruction, thyroid gland, using percutaneous
85.6 Mastopexy	(needle) approach and radioactive pharmaceutical agent [e.g. I-131,
	radioiodine]

Survival Analysis

Cancer patients were followed from the date of diagnosis to the end of the observation period of March 31, 2013, the date of loss of health insurance coverage due to death, or date of loss of health insurance coverage due to a move out of province, whichever came first. Multivariable Cox proportional hazards regression models were used to model time to death, stratified by cancer site (breast, colorectal, lung, prostate). The covariates included were age, sex, summary cancer stage, income quintile, weighted Charlson comorbidity score, number of ambulatory visits, number of inpatient hospitalizations, number of prescription dispensations, and number of ED visits. Healthcare use (physician visits, hospitalizations, prescriptions, and ED visits) were included in the regression models as baseline covariates counting the number of contacts in the year prior to cancer diagnosis date, as well as time–varying covariates counting the number of contacts at every six–month interval or portion thereof in the follow–up period. These regression models included cancer cases diagnosed from January 1, 2007 to December 31, 2011, and were limited to cancer patients age 18 and older who lived in Winnipeg on the date of their cancer diagnosis, and were continuously covered by Manitoba Health Insurance in the year prior to their cancer diagnosis.

APPENDIX 2: DATA QUALITY REPORT FOR MANITOBA CANCER REGISTRY DATA IN THE MCHP POPULATION HEALTH RESEARCH DATA REPOSITORY

Appendix Table 2.1: Overview of Manitoba Cancer Registry Data, 1984-2011

Dataset	Dataset Label	Number of Records	Number of Fields
CCMB_CANCER_19842003	Cancer Registry - 1984–2003	146,806	27
CCMB_CANCER_20042011	Cancer Registry - 2004–2011	71,980	27
CCMB_TREATMENT_1984JAN	Cancer Treatment- 1984–2011	432,530	8

Appendix Table 2.2: Valid, Invalid, Missing, and Outlier (VIMO) Table for Manitoba Cancer Registry Data, 1984-2011 Total number of records: 218,786

Tvne	Variable Name	Variahle Description	Valid	Invalid	Missing	Outlier	Potential Data	Minimum	Maximum	Mean	Median	Standard	Footnotes
лч <i>с</i> .			(%)	(%)	(%)	(%)	Quality Issues ¹					Deviation	
۵	FILEPHIN	MHHLS scrambled PHIN	100		0								
I	TUMOURID	Tumour ID number	100		0		None or Minimal (<5%)						
əı	ACQDT	Date first acquired at MCHP	100		0			2014-02-25	2014-02-25				2
вQ	BIRTHDT	Birth date (SAS)	100		00		None or Minimal (<5%)	1881-07-27	2011-12-03				m n
-	חאטו	Diagriosis date (2A2)	P P	I	>			TO-TO-+02T	TC-7T-TT07	T	I		n
ωnN	DXAGE	Age at diagnosis	99.77		0.0	0.23	None or Minimal (<5%)	0	109.00	65.74	68.35	16.18	
	AJCC6	AJCC summary stage 6th edition (2004 or later)	24.83		75.17		Significant (>30%)	IV, I, NA, II, 0, I	IV, I, NA, II, 0, IIA, IIIB, UNK, IA,	, IB			4
	AJCC7	AJCC summary stage 7th edition (2010 or later)	6.66		93.34		Significant (>30%)	IV, 0, IA, IIA, N	A, I, IIB, IIIB, IIIA,	, IB			4
	BIRDATST	Birth date status	100		0.0		None or Minimal (<5%)	C, D, M					3,4
	CANCER_SITE	Cancer site	100		0.0		None or Minimal (<5%)	Other skin and in sit colon excluding rect rectosigmoid, other, Hodgkin lymphoma	Other skin and in situ, breast, lung and bronchus, prostate, colon excluding rectum, cervix uteri, rectum and rectosigmoid, other, ill defined & unknown, bladder, non- Hodgkin lymphoma	lung and x uteri, re d & unkn	bronchus, ctum and own, bladc	prostate, ler, non-	4
	DX_CONFIRM	Diagnostic confirmation (2004 or later)	32.90		67.10		Significant (>30%)	histology, radii laboratory test unknown	histology, radiology, cytology, histology plus positive, laboratory test, death certificate, surgical, clinical, autopsy, unknown	, histolog ate, surgic	y plus posi al, clinical,	tive, autopsy,	4
	DXDATEST	Status of date of diagnosis	100	Γ	0.0		None or Minimal (<5%)	C. D. M					3.4
s.	DXMETHOD	Diagnosis method	100		0.0		None or Minimal (<5%)	histology, cytold surgical/clinical, clinical, surgical	histology, cytology, radiology/laboratory test, radiology, surgical/clinical, death certificate, laboratory test, autopsy, clinical, surgical	/laborato ate, labor	ry test, rad atory test,	iology, autopsy,	5 4
Character	DXPC	Postal code at diagnosis	100		0.0		None or Minimal (<5%)	R0J1H0, R0L1Z0, RC R0C2Z0, R0C1B0, R R0K2C0, R0K0E0, RU R0L0Y0, and others	ROJIHO, ROLIZO, ROAZAO, ROMZCO, ROEOCO, ROJIEO, ROGOJO, ROCZZO, ROCIBO, ROKIGO, ROGOBO, ROEIAO, ROLIPO, ROKZCO, ROKOEO, ROEOKO, ROKOHO, ROCOAO, ROMOMO, ROLOYO, and others	M2C0, R0 G0B0, R0 <0H0, R0(EOCO, ROJJ E1AO, ROLJ COAO, ROM	EO, ROGOJO, .PO, OMO,	4,5
_	FILEPHINTYPE	MCHP method to determine FILEPHIN	100		0.0		None or Minimal (<5%)	0					2,4
	GENDER	Gender	100		0.0		None or Minimal (<5%)	F, M					4
	LATERAL	Laterality of tumour	51.05		48.95		Significant (> 30%)	right, left, unkr	left, unknown, bilateral,	midline, unilatera	unilateral		4
	M6	Metastasis stage according to AJCC 6th edition	24.83		75.17		Significant (> 30%)	M0, NA, M1, N	M0, NA, M1, MX, M1b, M1c, M1a, M1NOS	И1a, M1h	SON		4
	M7	Metastasis stage according to AJCC 7th edition	6.66		93.34			M0, NA, M1b,	M0, NA, M1b, M1, M1a, M1c				4
	MALIGNUM	Malignant number or primary number	100		0.0		None or Minimal (<5%)	1, 2, 3, 4, 5, 6, 7	7, 8			00000	4
	MORPH3	ICD-O3 histology	100		0.0		None or Minimal (<5%)	81403, 80903, 80102, 81303	81403, 80903, 80703, 85003, 80103, 80003, 80702, 80973, 80102, 81303	80103, 80	003, 8070	2, 809/3,	3,4
	N6	Node stage according to AJCC 6th edition	24.83		75.17		Significant (> 30%)	NO, NA, N1, N	NA, N1, N2, NX, N1a, N3, N2a, N3a, N2b	N2a, N3á	a, N2b		4
	N7	Node stage according to AJCC 7th edition	6.66		93.34		Significant (> 30%)	N0, NA, N1, N.	NA, N1, N2, N1a, NX, N2a, N1b, N3, N2b	a, N1b, NE	3, N2b		4
	SEX	Sex of patient (MCHP)	100		0.0		None or Minimal (<5%)	2, 1					4
	Т6	Tumour stage according to AJCC 6th edition	24.83		75.17		Significant (>30%)		72, T3, Tis, T4, T1, T1c, TX, T1b, T1a	, T1b, T1a			4
	T7	Tumour stage according to AJCC 7th edition	6.66		93.34		Significant (>30%)	NA, T3, Tis, T2,	T1c, T1a, T1, T	[Za, T1b, T	×		4
	TOPOG	ICD-O3 topography (site)	100		0		None or Minimal (<5%)	c443, c619, c4	c443, c619, c448, c341, c421, c539, c509, c445, c504, c446	c539, c50	9, c445, c5	04, c446	3,4
	indicates number	indicates numbers used as identifiers for data linkage					1 indicates percent of values that could pose a data quality problem	es that could po	ise a data quali	ty problei	۶		
Num MHHLS MCHP		indicates numenc value indicates Manitoba Health, Healthy Living and Seniors indicates straible is created at the Manitoba Centre for Health Policy					 (i.e., sum of missing, invalid, and outlier values) variable has no variance or all values are missing indicates that no invalid values found 	ilid, and outlier v or all values are values found	<i>r</i> alues) missing				
SAS AUCC	indicates variable indicates the guid	indicates variable is calculated as SAS days indicates the quideline published by the American Joint Committee on Cancer	cer				 4 indicates top 10 observed values 5 all postal codes listed have frequency above 20 	d values ve frequency ab	ove 20				
No+0.	deiver of etch	- MAE MAT NIE NIT TE and TT in 2004-2009 are base	A no ho	ורר הוא ס	۲								

MCHP SAS AJCC Note:

indicates variable is calculated as SAS days indicates the guideline published by the American Joint Committee on Cancer data for variables M6, M7, N6, N7, T6, and T7 in 2004-2009 are based on AJCC 6th ed. and in 2010-2011 both on AJCC 6th and 7th ed.

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Variable	Description	Breast	Colorectal	Lung	Prostate	All Other Sites	Total
Tumour (T)	· · · ·						
ТХ	Primary tumour cannot be assessed	0.27	0.87	0.71	0.69	2.02	4.57
то	No evidence of primary tumour	0.03	0.01	0.06	0.01	0.13	0.24
Tis	Carcinoma in situ	1.40	0.72	0.01	0.00	4.05	6.17
Та	Non-invasive papillary carcinoma	0.00	0.00	0.00	0.00	1.48	1.48
T1, T2, T3, T4	Numbers correspond to the size of the primary tumour and its spread. Higher numbers indicated larger tumours and greater spread	9.13	8.36	9.15	7.59	18.09	52.32
NA	Not applicable	0.02	0.14	0.11	0.00	11.05	11.32
Missing	Missing data	0.00	0.00	0.00	0.00	23.91	23.91
Total		10.85	10.10	10.04	8.29	60.73	100
Lymph Node	s (N)				1		
NX	Regional lymph nodes cannot be assessed	0.24	0.43	0.55	0.43	1.15	2.81
N0	No evidence that regional lymph nodes are involved	7.57	5.99	4.21	7.53	21.00	46.30
N1, N2 or N3	The number corresponds to the degree of spread of cancer to the lymph nodes	3.02	3.54	5.17	0.33	3.60	15.66
NA	Not applicable	0.02	0.14	0.11	0.00	11.06	11.32
Missing	Missing data	0.00	0.00	0.00	0.00	23.91	23.91
Total		10.85	10.10	10.04	8.29	60.72	100
Metastasis (M)							
MX	Metastasis cannot be assessed	0.18	0.28	0.45	0.29	0.73	1.92
M0	No evidence of distant metastasis	10.12	7.82	5.32	7.36	21.75	52.37
M1	Distant metastasis is present	0.53	1.87	4.16	0.65	3.27	10.48
NA	Not applicable	0.02	0.14	0.11	0.00	11.05	11.32
Missing	Missing data	0.00	0.00	0.00	0.00	23.91	23.91
Total		10.85	10.11	10.04	8.30	60.71	100

Appendix Table 2.3: Percent of Cancer Stage Information by Cancer Site in the Manitoba Cancer Registry, 2004 – 2009

Variable	Description	Breast	Colorectal	Lung	Prostate	All Other Sites	Total
Tumour (T)	•						
тх	Primary tumour cannot be assessed	0.22	0.70	0.39	0.54	1.51	3.35
то	No evidence of primary tumour	0.04	0.02	0.07	0.03	0.14	0.29
Tis	Carcinoma in situ	1.20	2.48	0.00	0.00	4.83	8.51
Та	Non-invasive papillary carcinoma	0.00	0.00	0.00	0.00	1.45	1.45
T1, T2, T3, T4	Numbers correspond to the size of the primary tumour and its spread. Higher numbers indicated larger tumours and greater spread	8.78	8.30	8.44	6.87	17.93	50.32
NA	Not applicable	0.02	0.02	0.02	0.00	9.85	9.91
Missing	Missing data	0.00	0.00	0.00	0.00	26.17	26.17
Total		10.26	11.52	8.92	7.44	61.88	100
Lymph Nodes	; (N)						
NX	Regional lymph nodes cannot be assessed	0.19	0.39	0.16	0.26	0.71	1.70
N0	No evidence that regional lymph nodes are involved	7.02	7.60	4.16	6.65	21.31	46.74
N1, N2 or N3	The number corresponds to the degree of spread of cancer to the lymph nodes	3.03	3.50	4.58	0.53	3.85	15.48
NA	Not applicable	0.02	0.02	0.02	0.00	9.85	9.90
Missing	Missing data	0.00	0.00	0.00	0.00	26.17	26.17
Total		10.26	11.51	8.92	7.44	61.89	100
Metastasis (N	1)		· · · · · · · · · · · · · · · · · · ·				
M0	No evidence of distant metastasis	9.66	9.77	4.37	6.70	22.73	53.24
M1	Distant metastasis is present	0.57	1.72	4.53	0.73	3.14	10.69
NA	Not applicable	0.02	0.02	0.02	0.00	9.85	9.90
Missing	Missing data	0.00	0.00	0.00	0.00	26.17	26.17
Total		10.25	11.51	8.92	7.43	61.89	100

Appendix Table 2.4: Percent of Cancer Stage Information by Cancer Site in the Manitoba Cancer Registry, 2010–2011

Summary Stage	Description	Breast	Colorectal	Lung	Prostate	All Other Sites	Total
	•	20	04 – 2009				
Occult	Primary tumour cannot be evaluated	0.00	0.00	0.11	0.00	0.00	0.11
0	Carcinoma in situ	1.40	0.72	0.01	0.00	5.52	7.64
Ι	Stage 1 (least severe)	3.93	1.79	2.17	0.02	9.27	17.17
II	Stage 2	3.46	2.55	0.52	5.88	3.66	16.07
III	Stage 3	1.22	2.56	2.50	0.77	3.32	10.37
IV	Stage 4 (most severe)	0.53	1.87	4.16	0.92	5.48	12.97
Unk	Insufficient data	0.28	0.48	0.47	0.71	1.72	3.66
NA	Not applicable	0.02	0.14	0.11	0.00	7.84	8.11
Missing	Missing data	0.00	0.00	0.00	0.00	23.91	23.91
Total		10.84	10.11	10.05	8.30	60.72	100
	-	20	10 - 2011				
Occult	Primary tumour cannot be evaluated	0.00	0.00	0.04	0.00	0.00	0.04
0	Carcinoma in situ	1.20	2.48	0.00	0.00	6.27	9.95
Ι	Stage 1 (least severe)	3.73	1.90	1.98	1.28	9.11	18.01
II	Stage 2	3.26	2.41	0.86	3.88	3.42	13.82
III	Stage 3	1.32	2.56	1.37	0.75	3.61	9.62
IV	Stage 4 (most severe)	0.57	1.72	4.53	1.11	5.35	13.27
Unk	Insufficient data	0.15	0.42	0.13	0.42	0.96	2.07
NA	Not applicable	0.02	0.02	0.02	0.00	7.00	7.06
Missing	Missing data	0.00	0.00	0.00	0.00	26.17	26.17
Total		10.25	11.51	8.93	7.44	61.89	100

Appendix Table 2.5: Summary Cancer Stage (%) by Cancer Site in the Manitoba Cancer Registry, 2004-2011

Appendix Table 2.6: Valid, Invalid, Missing, and Outlier (VIMO) Table for Manitoba Cancer Treatment Data, 1984-2011 Total number of records: 432,530

				Í	Í	Î							
ł			Valid	Invalid	Valid Invalid Missing Outlier	Outlier	Potential Data			;	:	Standard	
Type	e Variable Name	Variable Description	(%)	(%)	(%)	(%)	Quality Issues ¹	Minimum	Maximum Mean Median	Mean		Deviation	Footnotes
¢	FILEPHIN	MHHLS Scrambled PHIN	100		0		None or Minimal (<5%)						
11	TUMOURID	Tumour ID number	100		0		None or Minimal (<5%)						
91ı	АСQDT	Date first acquired at MCHP	100		0		None or Minimal (<5%)	2014-02-25	2014-02-25 2014-02-25				2
۵	TXDT	Treatment Date	100	0	0		None or Minimal (<5%)	1900-01-01	2066-05-16				С
ters	CCI	Canadian Classification of Health Interventions (2005 or later)	34		99		Significant (>30%)	1ZZ35HAM0, 1 1ZZ35CAM0, 1	1ZZ35HAM0, 1ZZ35CAM6, 1YF87LA, 1YS87LA, 1YD87LA, 1ZZ35CAM0, 1YT87LA, 1YB87LA, 1YM87LA, 1YM27JA	/F87LA, 1Y 1A, 1YM8	/S87LA, 1YI 7LA, 1YM2	D87LA, :7JA	
rac	FILEPHINTYPE	MCHP Method to determine FILEPHIN	100		0		None or Minimal (<5%)	0					2
ey:	TXDATEST	Treatment Date Status	100		0		None or Minimal (<5%)	c, d, m, y					
)	TXICD9	ICD-9 Procedure code (1984-2004)	66		34		Significant (>30%)	863, 9925, 992	863, 9925, 9924, 9224, 9223, 2132, 8521, 5749, 8543, 403	2132, 852:	1, 5749, 85	43, 403	
0	indicates numbe	indicates numbers used as identifiers for data linkage						1 percent of v	percent of values that could pose a data quality problem	ld pose a	data qualit	:y problem	
Num	indicates numeric value	ric value						(i.e., sum of	(i.e., sum of missing, invalid, and outlier values)	d, and out	tlier values	(

indicates Manitoba Health, Healthy Living and Seniors indicates variable is created at the Manitoba Centre for Health Policy Num MHHLS MCHP

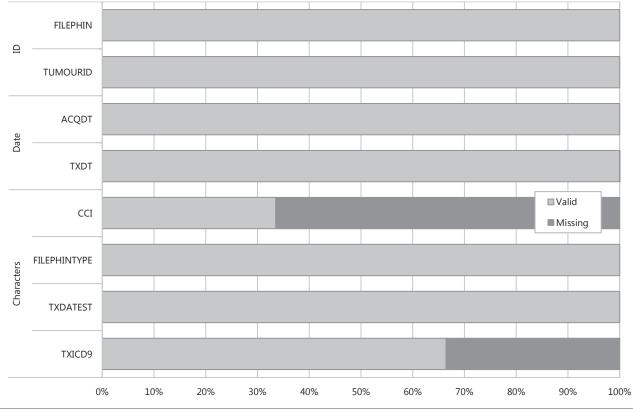
(ue., sum of missing, invalid, and outlier values) variable has no variance or all values are missing variable has 2 invalid observations (2021-07-20, 2066-05-16)

Ν

ACQDT IRTHDT DXDT DXAGE AJCC6 AJCC7 RDATST ER_SITE										
IRTHDT DXDT DXAGE AJCC6 AJCC7 RDATST										
IRTHDT DXDT DXAGE AJCC6 AJCC7 RDATST										
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ONFIRM										
DATEST									■ Valid	
IETHOD										
DXPC *									Missing	
IINTYPE									J	
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ATERAL		I							1	
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IGNUM	· · · · · ·	I			I					
IORPH3		I			I					
N6										
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c	T6 T7	Т6	T6	T6 T7	T6 T7	T6 T7	T6 T7	T6 T7	T6 T7	T6 T7

Appendix Figure 2.1: Distribution of Valid, Invalid, Missing and Outlier Values for Manitoba Cancer Registry Data, 1984-2011

Appendix Figure 2.2: Distribution of Valid, Invalid, Missing and Outlier Values for Manitoba Cancer Treatment Data, 1984-2011



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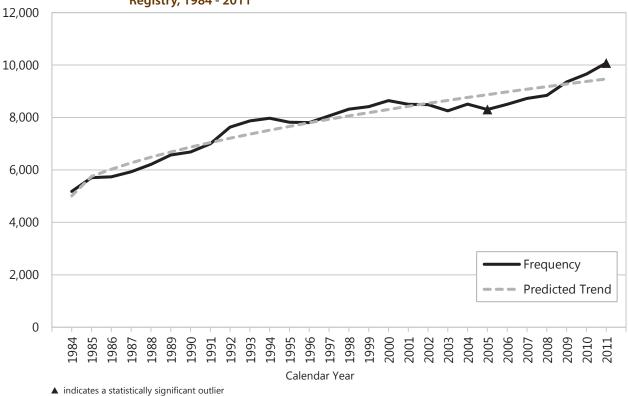
Dataset	Total Number of Records	Number of Linkable Records	% of Linkable Records	Number of Linkable Individuals
Cancer Registry (1984-2003)	146,806	146,806	100	125,874
Cancer Registry (2004-2011)	71,980	71,980	100	64,644
Cancer Treatment (1984-2011)	432,530	432,530	100	150,387

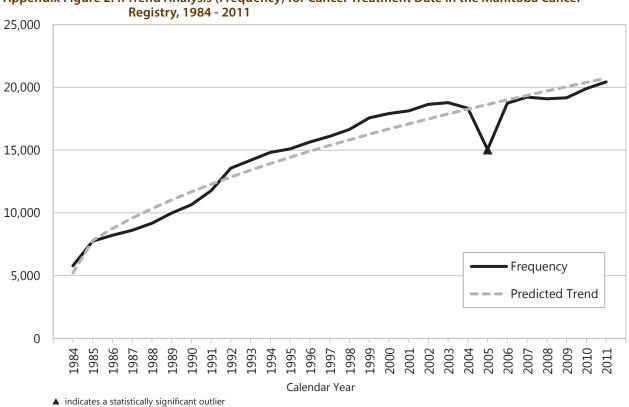
Appendix Table 2.7: Linkability of the Manitoba Cancer Registry Data, 1984-2011

Appendix Table 2.8: Agreement of Sex and Date of Birth Variables Between Manitoba Cancer Registry and Manitoba Health Insurance Registry

Dataset		nent (Kappa) with a Registry
	Sex	Date of Birth
CCMB_CANCER_1984JAN	1.000	0.966

Appendix Figure 2.3: Trend Analysis for Frequency of Cancer Diagnosis Date in the Manitoba Cancer Registry, 1984 - 2011





Appendix Figure 2.4: Trend Analysis (Frequency) for Cancer Treatment Date in the Manitoba Cancer

Appendix Table 2.9: Frequency of Error Messages for Validation Checks on Data Consistency in the Manitoba Cancer Registry Data, 1984-2011

Error Message	Frequency
Patient received treatment at age 120 years and older	1
Treatment date start before patient's birth date	4*
Treatment date start before diagnosis date (based on complete diagnosis and treatment date)	398**
Treatment date start before diagnosis date (based on complete diagnosis and treatment date and patient's birth date is between Jan 1, 1984 and Dec 31, 2011)	3

* Not a problem, all 4 records have a treatment date of 1900-01-01, which represent missing year, month, day in Cancer Registry data

** Probably not a problem, Cancer Registry was extracted based on diagnosis date between Jan 1, 1984 and Dec 31, 2011, there could be a diagnosis date earlier than Jan 1, 1984

			Treatme	ent Data		
Month	20	04	20	05	20	06
	N	%	Ν	%	N	%
1	3,549	19.3	2,575	17.1	3,438	18.3
2	1,262	6.9	1,001	6.7	1,325	7.1
3	1,450	7.9	1,059	7.0	1,398	7.5
4	1,261	6.9	1,176	7.8	1,290	6.9
5	1,387	7.6	1,180	7.8	1,572	8.4
6	1,401	7.6	1,195	7.9	1,500	8.0
7	1,222	6.7	1,003	6.7	1,284	6.9
8	1,338	7.3	1,092	7.3	1,377	7.4
9	1,473	8.0	1,208	8.0	1,416	7.6
10	1,274	6.9	1,204	8.0	1,464	7.8
11	1,482	8.1	1,249	8.3	1,491	8.0
12	1,247	6.8	1,105	7.3	1,188	6.3

Appendix Table 2.10: Frequency (%) of Treatment Records by Month in the Manitoba Cancer Registry Data, 2004–2006

		Number	of Patients	
Cancer Site	Fem	nales	Ма	les
	N	%	N	%
Acute lymphocytic leukemia	165	0.08	229	0.1
Acute myeloid leukemia	458	0.21	543	0.25
Anus	243	0.11	140	0.06
Bladder	1,633	0.75	4,860	2.22
Bones and joints	125	0.06	153	0.07
Brain	865	0.4	1,120	0.51
Breast	22,224	10.16	153	0.07
Cervix uteri	10,801	4.94	n/a	n/a
Chronic lymphocytic leukemia	880	0.4	1,287	0.59
Chronic myeloid leukemia	180	0.08	274	0.13
Colon excluding rectum	7,314	3.34	7,435	3.4
Corpus uteri	4,535	2.07	n/a	n/a
Esophagus	370	0.17	935	0.43
Eye	156	0.07	157	0.07
Floor of mouth	95	0.04	200	0.09
Gallbladder	405	0.19	162	0.07
Gum and other mouth	257	0.12	285	0.13
Hodgkin lymphoma	355	0.16	429	0.2
Hypopharynx	51	0.02	238	0.11
Kaposi sarcoma	14	0.01	88	0.04
Kidney	1,666	0.76	2,853	1.3
Larynx	177	0.08	906	0.41
Lip	303	0.14	1,291	0.59
Liver	284	0.13	690	0.32
Lung and bronchus	9,021	4.12	12,432	5.68
Major salivary gland	135	0.06	150	0.07
Melanomas of the skin	2,268	1.04	2,357	1.08
Mesothelioma	65	0.03	297	0.14
Multiple myeloma	831	0.38	1,022	0.47
Nasopharynx	58	0.03	140	0.06
Non-Hodgkin lymphoma	2,904	1.33	3,214	1.47
Oropharynx	26	0.01	80	0.04
Other buccal cavity and pharynx	112	0.05	338	0.15
Other digestive system	642	0.29	614	0.28
Other endocrine	82	0.04	98	0.04
Other female genital system	1,206	0.55	n/a	n/a
Other leukemias	213	0.1	292	0.13
Other male genital system	n/a	n/a	57	0.03
Other nervous system	64	0.03	61	0.03
Other respiratory system	113	0.05	183	0.08
Other skin and in situ	24,913	11.39	28,960	13.24
Other urinary system	38	0.02	90	0.04
Other, ill defined & unknown	3,316	1.52	3,371	1.54
Ovary	2,299	1.05	n/a	n/a
Penis	n/a	n/a	221	0.1
Prostate	n/a	n/a	19,356	8.85
Rectum and rectosigmoid	2,766	1.26	4,211	1.92

Appendix Table 2.11: Frequency (%) of Patients Diagnosed with Cancer by Cancer Site and Sex, 1984-2011

n/a indicates not applicable

Appendix Table 2.11: Continued

		Number of Patients					
Cancer Site	Fen	nales	Ma	ales			
	Ν	%	N	%			
Pancreas	1,803	0.82	1,810	0.83			
Small intestine	257	0.12	299	0.14			
Soft tissue (including heart)	346	0.16	442	0.2			
Stomach	1,189	0.54	2,248	1.03			
Testis	n/a	n/a	818	0.37			
Thyroid	1,417	0.65	460	0.21			
Tongue	275	0.13	481	0.22			
Ureter	84	0.04	135	0.06			
Uterus, NOS	122	0.06	n/a	n/a			

n/a indicates not applicable

APPENDIX 3: POISSON REGRESSION MODEL RESULTS FOR EMERGENCY DEPARTMENT USE IN THE PRE-, PERI- AND POST-DIAGNOSIS PERIODS

Regression Models Results for Cancer Cohorts and Matched Cancer-Free Cohorts

Appendix Table 3.1: Poisson Regression Model Results for Emergency Department Use, Breast Cancer **Cohort and Matched Cancer-Free Cohort** W

Vinnipeg residents, 2007/08-2010/11	
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Model Covariates	Relative Rate (95%	p-value
	Confidence Interval)	p-value
Intercept	0.01 (0.01, 0.01)	<0.0001
Month of Diagnosis	0.99 (0.98, 0.99)	0.0008
Cancer Cohort (ref = Matched Cancer-Free Cohort)	1.11 (0.93, 1.32)	0.2553
Time Period (ref = Pre-Diagnosis)		
Peri-Diagnosis Period	1.00 (0.76, 1.31)	0.9923
Post-Diagnosis Period	1.37 (1.11, 1.70)	0.0034
Interaction of Cohort and Time Period		
(ref = Matched Cancer-Free Cohort in Pre-Diagnosis Period)		
Cancer Cohort in Peri-Diagnosis Period	1.57 (1.15, 2.16)	0.0050
Cancer Cohort in Post-Diagnosis Period	1.31 (1.06, 1.61)	0.0108
Age	1.00 (1.00, 1.01)	0.1760
Sex (ref = Female)	1.07 (0.71, 1.61)	0.7359
Income Quintile (ref = Q5 (highest))		
Q1 (lowest)	1.58 (1.38, 1.82)	<0.0001
Q2	1.48 (1.28, 1.72)	<0.0001
Q3	1.40 (1.21, 1.62)	<0.0001
Q4	1.21 (1.04, 1.40)	0.0138
Income Unknown	0.93 (0.75, 1.15)	0.4803
Charlson Index	1.27 (1.23, 1.32)	<0.0001
Number of Inpatient Hospitalizations	4.25 (3.89, 4.64)	<0.0001
Majority of Care	0.93 (0.85, 1.01)	0.0763
Number of Ambulatory Physician Visits	1.35 (1.32, 1.38)	<0.0001
Number of Prescription Drug Dispensations	1.02 (1.02, 1.03)	<0.0001
Comparison Tests	Relative Rate (95%	n value
•	Confidence Interval)	p-value
Cancer Cohort vs. Matched Cancer-Free Cohort		
Overall	1.41 (1.18, 1.68)	0.0001
Pre-Diagnosis Period	1.11 (0.82, 1.50)	0.5088
Peri-Diagnosis Period	1.74 (1.31, 2.32)	0.0001
Post-Diagnosis Period	1.45 (1.26, 1.67)	<0.0001
Cancer Cohort: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	1.58 (1.16, 2.14)	0.0035
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.79 (1.33, 2.43)	0.0002
Post-Diagnosis Period vs. Peri-Diagnosis Period	1.14 (0.93, 1.39)	0.2087
Matched Cancer-Free Cohort: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	1.00 (0.78, 1.28)	0.9916
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.37 (1.10, 1.71)	0.0052
Post-Diagnosis Period vs. Peri-Diagnosis Period	1.37 (1.07, 1.75)	0.0110

Appendix Table 3.2: Poisson Regression Model Results for Emergency Department Use, Colorectal Cancer Cohort and Matched Cancer-Free Cohort

Winnipeg residents,	2007/08-2010/11
winnipeg residents,	2007/00-2010/11

Madel Constants	Relative Rate (95%	
Model Covariates	Confidence Interval)	p-value
Intercept	0.02 (0.02, 0.03)	< 0.0001
Month of Diagnosis	0.99 (0.99, 1.00)	0.1207
Cancer Cohort (ref = Matched Cancer-Free Cohort)	1.18 (1.01, 1.37)	0.0381
Time Period (ref = Pre-Diagnosis)		
Peri-Diagnosis Period	1.17 (0.94, 1.46)	0.1657
Post-Diagnosis Period	1.21 (1.00, 1.47)	0.0505
Interaction of Cohort and Time Period		
(ref = Matched Cancer-Free Cohort in Pre-Diagnosis Period)		
Cancer Cohort in Peri-Diagnosis Period	2.07 (1.60, 2.68)	<0.0001
Cancer Cohort in Post-Diagnosis Period	1.19 (0.99, 1.43)	0.0635
Age	1.00 (0.99, 1.00)	0.0455
Sex (ref = Female)	0.94 (0.87, 1.02)	0.1299
Income Quintile (ref = Q5 (highest))		
Q1 (lowest)	1.57 (1.38, 1.78)	<0.0001
Q2	1.53 (1.34, 1.75)	< 0.0001
Q3	1.35 (1.18, 1.54)	< 0.0001
Q4	1.17 (1.01, 1.34)	0.0317
Income Unknown	0.95 (0.77, 1.17)	0.6217
Charlson Index	1.17 (1.14, 1.19)	< 0.0001
Number of Inpatient Hospitalizations	3.23 (3.02, 3.46)	< 0.0001
Majority of Care	0.86 (0.79, 0.93)	< 0.0001
Number of Ambulatory Physician Visits	1.31 (1.29, 1.34)	< 0.0001
Number of Prescription Drug Dispensations	1.03 (1.03, 1.03)	< 0.0001
Communities Tosts	Relative Rate (95%	
Comparison Tests	Confidence Interval)	p-value
Cancer Cohort vs. Matched Cancer-Free Cohort		
Overall	1.59 (1.28, 1.98)	<0.0001
Pre-Diagnosis Period	1.18 (0.92, 1.50)	0.1886
Peri-Diagnosis Period	2.44 (1.72, 3.45)	<0.0001
Post-Diagnosis Period	1.40 (1.11, 1.76)	0.0047
Cancer Cohort: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	2.43 (2.04, 2.88)	<0.0001
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.44 (1.17, 1.77)	0.0005
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.59 (0.52, 0.68)	<0.0001
Matched Cancer-Free Cohort: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	1.17 (0.87, 1.58)	0.3059
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.21 (0.99, 1.48)	0.0613
Post-Diagnosis Period vs. Peri-Diagnosis Period	1.04 (0.74, 1.45)	0.8377

Appendix Table 3.3: Poisson Regression Model Results for Emergency Department Use, Lung Cancer Cohort and Matched Cancer-Free Cohort

Winnipeg resident	s, 2007/08-2010/11
winnipeg resident.	3, 2007/00 2010/11

Winnipeg residents, 2007/08-2010/11	Relative Rate (95%	
Model Covariates	Confidence Interval)	p-value
Intercept	0.01 (0.01, 0.01)	< 0.0001
Month of Diagnosis	0.99 (0.98, 1.00)	0.0040
Cancer Cohort (ref = Matched Cancer-Free Cohort)	1.38 (1.21, 1.57)	< 0.0001
Time Period (ref = Pre-Diagnosis)		
Peri-Diagnosis Period	1.07 (0.86, 1.32)	0.5446
Post-Diagnosis Period	1.24 (1.04, 1.49)	0.0163
Interaction of Cohort and Time Period		
(ref = Matched Cancer-Free Cohort in Pre-Diagnosis Period)		
Cancer Cohort in Peri-Diagnosis Period	3.26 (2.58, 4.13)	<0.0001
Cancer Cohort in Post-Diagnosis Period	1.65 (1.40, 1.94)	<0.0001
Age	1.01 (1.01, 1.02)	<0.0001
Sex (ref = Female)	0.97 (0.90, 1.03)	0.2998
Income Quintile (ref = Q5 (highest))		
Q1 (lowest)	1.45 (1.29, 1.63)	<0.0001
Q2	1.36 (1.21, 1.54)	< 0.0001
Q3	1.34 (1.18, 1.51)	< 0.0001
Q4	1.11 (0.97, 1.26)	0.1270
Income Unknown	0.84 (0.68, 1.04)	0.1035
Charlson Index	1.16 (1.14, 1.18)	< 0.0001
Number of Inpatient Hospitalizations	3.20 (3.01, 3.41)	<0.0001
Majority of Care	0.92 (0.86, 0.99)	0.0164
Number of Ambulatory Physician Visits	1.28 (1.26, 1.31)	<0.0001
Number of Prescription Drug Dispensations	1.02 (1.01, 1.02)	<0.0001
Commerciaen Tests	Relative Rate (95%	n value
Comparison Tests	Confidence Interval)	p-value
Cancer Cohort vs. Matched Cancer-Free Cohort		
Overall	2.42 (2.13, 2.75)	<0.0001
Pre-Diagnosis Period	1.38 (1.18, 1.62)	<0.0001
Peri-Diagnosis Period	4.51 (3.61, 5.63)	<0.0001
Post-Diagnosis Period	2.28 (1.94, 2.67)	< 0.0001
Cancer Cohort: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	3.48 (3.00, 4.04)	< 0.0001
Post-Diagnosis Period vs. Pre-Diagnosis Period	2.05 (1.68, 2.49)	<0.0001
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.59 (0.51, 0.68)	<0.0001
Matched Cancer-Free Cohort: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	1.07 (0.87, 1.32)	0.5357
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.24 (0.99, 1.57)	0.0661
Post-Diagnosis Period vs. Peri-Diagnosis Period	1.16 (0.92, 1.47)	0.1954

Appendix Table 3.4: Poisson Regression Model Results for Emergency Department Use, Prostate Cancer Cohort and Matched Cancer-Free Cohort

Winnipeg residents	2007/08-2010/11
winnipeg residents	, 2007,00 2010,11

	Relative Rate (95%	
Model Covariates	Confidence Interval)	p-value
Intercept	0.00 (0.00, 0.00)	< 0.0001
Month of Diagnosis	1.00 (0.99, 1.00)	0.3507
Cancer Cohort (ref = Matched Cancer-Free Cohort)	1.14 (0.97, 1.35)	0.1161
Time Period (ref = Pre-Diagnosis)		
Peri-Diagnosis Period	0.65 (0.48, 0.89)	0.0068
Post-Diagnosis Period	1.11 (0.90, 1.38)	0.3365
Interaction of Cohort and Time Period		
(ref = Matched Cancer-Free Cohort in Pre-Diagnosis Period)		
Cancer Cohort in Peri-Diagnosis Period	2.71 (1.91, 3.84)	<0.0001
Cancer Cohort in Post-Diagnosis Period	1.05 (0.86, 1.28)	0.6541
Age	1.02 (1.01, 1.02)	< 0.0001
Income Quintile (ref = Q5 (highest))		
Q1 (lowest)	1.78 (1.55, 2.04)	< 0.0001
Q2	1.20 (1.03, 1.39)	0.0183
Q3	1.21 (1.04, 1.40)	0.0138
Q4	1.11 (0.96, 1.29)	0.1634
Income Unknown	0.82 (0.66, 1.04)	0.0960
Charlson Index	1.20 (1.16, 1.23)	< 0.0001
Number of Inpatient Hospitalizations	5.41 (4.98, 5.89)	< 0.0001
Majority of Care	0.96 (0.88, 1.05)	0.4009
Number of Ambulatory Physician Visits	1.38 (1.35, 1.42)	<0.0001
Number of Prescription Drug Dispensations	1.02 (1.01, 1.02)	< 0.0001
	Relative Rate (95%	
Comparison Tests	Confidence Interval)	p-value
Cancer Cohort vs. Matched Cancer-Free Cohort		
Overall	1.62 (1.35, 1.94)	<0.0001
Pre-Diagnosis Period	1.14 (0.93, 1.41)	0.2157
Peri-Diagnosis Period	3.10 (2.14, 4.47)	<0.0001
Post-Diagnosis Period	1.20 (0.98, 1.46)	0.0842
Cancer Cohort: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	1.77 (1.42, 2.20)	< 0.0001
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.16 (0.93, 1.46)	0.1934
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.66 (0.53, 0.82)	0.0002
Matched Cancer-Free Cohort: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	0.65 (0.47, 0.91)	0.0126
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.11 (0.84, 1.46)	0.4565
Post-Diagnosis Period vs. Peri-Diagnosis Period	1.70 (1.18, 2.46)	0.0043

Regression Model Results for Cancer Cohorts

Appendix Table 3.5: Poisson Regression Model Results for Emergency Department Use, Breast Cancer

Cohort Winnipeg residents, 2007/08-2010/11

Winnipeg residents, 2007/08-2010/11	Relative Rate (95%	
Model Covariates	Confidence Interval)	p-value
Intercept	0.01 (0.00, 0.02)	<0.0001
Month of Diagnosis	0.98 (0.97, 0.99)	0.0008
Time Period (ref = Pre-Diagnosis)		
Peri-Diagnosis Period	9.89 (4.77, 20.50)	<0.0001
Post-Diagnosis Period	6.80 (3.22, 14.36)	<0.0001
Age	1.00 (1.00, 1.01)	0.8312
Sex (ref = Female)	1.29 (0.76, 2.17)	0.3422
Income Quintile (ref = Q5 (highest))		
Q1 (lowest)	1.48 (1.22, 1.79)	<0.0001
Q2	1.47 (1.21, 1.79)	0.0001
Q3	1.34 (1.10, 1.64)	0.0041
Q4	1.26 (1.03, 1.54)	0.0230
Income Unknown	1.02 (0.78, 1.34)	0.8812
Charlson Index	1.22 (1.16, 1.28)	<0.0001
Number of Inpatient Hospitalizations	3.69 (3.31, 4.11)	<0.0001
Majority of Care	0.98 (0.88, 1.10)	0.7654
Number of Ambulatory Physician Visits	1.26 (1.22, 1.30)	<0.0001
Number of Prescription Drug Dispensations	1.02 (1.02, 1.03)	<0.0001
Cancer Stage (ref = Stage 4)		
Stage 1	2.88 (1.40, 5.93)	0.0040
Stage 2	2.69 (1.31, 5.52)	0.0071
Stage 3	1.81 (0.80, 4.07)	0.1523
Unknown Stage	2.42 (0.88, 6.63)	0.0863
Chemotherapy Treatment	0.98 (0.84, 1.15)	0.8116
Hormone Therapy Treatment	0.80 (0.71, 0.90)	0.0002
Radiation Therapy Treatment	0.89 (0.78, 1.02)	0.0874
Surgical Intervention	0.84 (0.66, 1.06)	0.1377
Interactions of Cancer Stage and Time Period	Relative Rate (95%	p-value
(ref = Stage 4, Pre-Diagnosis Period)	Confidence Interval)	
Stage 1*Peri-Diagnosis Period	0.08 (0.04, 0.19)	<0.0001
Stage 1*Post-Diagnosis Period	0.22 (0.10, 0.47)	<0.0001
Stage 2*Peri-Diagnosis Period	0.17 (0.08, 0.37)	<0.0001
Stage 2*Post-Diagnosis Period	0.31 (0.14, 0.66)	0.0024
Stage 3*Peri-Diagnosis Period	0.37 (0.15, 0.89)	0.0265
Stage 3*Post-Diagnosis Period	0.60 (0.26, 1.42)	0.2472
Unknown Cancer Stage*Peri-Diagnosis Period	0.24 (0.07, 0.84)	0.0251
Unknown Cancer Stage*Post-Diagnosis Period	0.18 (0.05, 0.61)	0.0061

Appendix Table 3.5: Continued

Comparison Tests	Relative Rate (95%	m velve
Comparison Tests	Confidence Interval)	p-value
Cancer Stages 3-4 vs. 1-2		
Overall	1.20 (0.92, 1.56)	0.1869
Pre-Diagnosis Period	0.48 (0.29, 0.80)	0.0050
Peri-Diagnosis Period	2.44 (1.74, 3.43)	<0.0001
Post-Diagnosis Period	1.45 (1.14, 1.85)	0.0025
Cancer Stages 1-2: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	1.19 (0.85, 1.66)	0.3246
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.76 (1.23, 2.51)	0.0020
Post-Diagnosis Period vs. Peri-Diagnosis Period	1.48 (1.15, 1.91)	0.0026
Cancer Stages 3-4: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	6.00 (3.78, 9.54)	<0.0001
Post-Diagnosis Period vs. Pre-Diagnosis Period	5.28 (3.27, 8.52)	<0.0001
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.88 (0.65, 1.20)	0.4124

Appendix Table 3.6: Poisson Regression Model Results for Emergency Department Use, Colorectal Cancer Cohort Winning residents, 2007/08-2010/11

Model Covariates	Relative Rate (95%	n volue
INIODEI COVARIATES	Confidence Interval)	p-value
Intercept	0.03 (0.02, 0.04)	<0.0001
Month of Diagnosis	0.99 (0.98, 0.99)	0.0004
Time Period (ref = Pre-Diagnosis)		
Peri-Diagnosis Period	5.66 (4.32, 7.42)	<0.0001
Post-Diagnosis Period	4.10 (3.07, 5.47)	<0.0001
Age	1.00 (1.00, 1.00)	0.6055
Sex (ref = Female)	0.91 (0.84, 0.99)	0.0287
Income Quintile (ref = Q5 (highest))		
Q1 (lowest)	1.21 (1.06, 1.38)	0.0060
Q2	1.17 (1.02, 1.34)	0.0300
Q3	1.15 (1.00, 1.32)	0.0434
Q4	1.01 (0.87, 1.17)	0.9216
Income Unknown	0.83 (0.67, 1.02)	0.0705
Charlson Index	1.10 (1.07, 1.13)	< 0.0001
Number of Inpatient Hospitalizations	3.04 (2.83, 3.28)	<0.0001
Majority of Care	1.00 (0.92, 1.08)	0.9433
Number of Ambulatory Physician Visits	1.23 (1.20, 1.27)	<0.0001
Number of Prescription Drug Dispensations	1.03 (1.03, 1.04)	< 0.0001
Cancer Stage (ref = Stage 4)		
Stage 1	1.31 (0.94, 1.83)	0.1047
Stage 2	1.75 (1.33, 2.31)	<0.0001
Stage 3	1.60 (1.20, 2.13)	0.0013
Unknown Stage	1.89 (1.35, 2.65)	0.0002
Chemotherapy Treatment	0.85 (0.76, 0.95)	0.0051
Radiation Therapy Treatment	1.06 (0.95, 1.18)	0.2833
Surgical Intervention	0.65 (0.57, 0.73)	<0.0001
Interactions of Cancer Stage and Time Period	Relative Rate (95%	p-value
(ref = Stage 4, Pre-Diagnosis Period)	Confidence Interval)	p value
Stage 1*Peri-Diagnosis Period	0.40 (0.26, 0.60)	<0.0001
Stage 1*Post-Diagnosis Period	0.36 (0.25, 0.53)	<0.0001
Stage 2*Peri-Diagnosis Period	0.45 (0.32, 0.62)	<0.0001
Stage 2*Post-Diagnosis Period	0.33 (0.24, 0.45)	<0.0001
Stage 3*Peri-Diagnosis Period	0.46 (0.33, 0.65)	<0.0001
Stage 3*Post-Diagnosis Period	0.49 (0.35, 0.67)	<0.0001
Unknown Cancer Stage*Peri-Diagnosis Period	0.40 (0.25, 0.64)	0.0001
Unknown Cancer Stage*Post-Diagnosis Period	0.28 (0.18, 0.43)	<0.0001

Appendix Table 3.6: Continued

Comparison Tasts	Relative Rate (95%	n voluo
Comparison Tests	Confidence Interval)	p-value
Cancer Stages 3-4 vs. 1-2		
Overall	1.24 (1.07, 1.43)	0.0038
Pre-Diagnosis Period	0.83 (0.65, 1.07)	0.1535
Peri-Diagnosis Period	1.35 (1.12, 1.62)	0.0014
Post-Diagnosis Period	1.69 (1.41, 2.01)	<0.0001
Cancer Stages 1-2: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	2.38 (1.88, 3.02)	<0.0001
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.42 (1.09, 1.84)	0.0084
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.60 (0.49, 0.72)	<0.0001
Cancer Stages 3-4: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	3.85 (3.06, 4.83)	<0.0001
Post-Diagnosis Period vs. Pre-Diagnosis Period	2.86 (2.22, 3.70)	<0.0001
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.74 (0.63, 0.88)	0.0007

Model Covariates	Relative Rate (95%	p-value
	Confidence Interval)	
Intercept	0.02 (0.01, 0.03)	< 0.000
Month of Diagnosis	1.00 (0.99, 1.01)	0.5692
Time Period (ref = Pre-Diagnosis)		
Peri-Diagnosis Period	5.59 (4.65, 6.73)	< 0.000
Post-Diagnosis Period	2.81 (2.21, 3.59)	< 0.000
Age	1.01 (1.00, 1.01)	0.0052
Sex (ref = Female)	0.99 (0.91, 1.09)	0.9029
Income Quintile (ref = Q5 (highest))		
Q1 (lowest)	1.26 (1.05, 1.50)	0.0121
Q2	1.32 (1.10, 1.58)	0.0032
Q3	1.25 (1.04, 1.51)	0.0190
Q4	1.08 (0.88, 1.32)	0.4522
Income Unknown	1.04 (0.76, 1.41)	0.8248
Charlson Index	1.11 (1.07, 1.14)	<0.000
Number of Inpatient Hospitalizations	2.42 (2.22, 2.64)	<0.000
Majority of Care	0.94 (0.86, 1.03)	0.2010
Number of Ambulatory Physician Visits	1.20 (1.16, 1.23)	< 0.000
Number of Prescription Drug Dispensations	1.02 (1.02, 1.03)	<0.000
Cancer Stage (ref = Stage 4)		
Stage 1	1.31 (1.03, 1.68)	0.0308
Stage 2	0.96 (0.57, 1.61)	0.8767
		1

0.88 (0.69, 1.12)

1.02 (0.62, 1.70)

0.93 (0.82, 1.05)

1.04 (0.94, 1.16)

0.66 (0.57, 0.77)

Relative Rate (95%

Confidence Interval)

0.25 (0.18, 0.36)

0.39 (0.28, 0.53)

0.49 (0.25, 0.96)

0.75 (0.41, 1.35)

0.68 (0.50, 0.92)

0.89 (0.66, 1.22)

0.77 (0.40, 1.48)

1.13 (0.61, 2.11)

Appendix Table 3.7: Poisson Regression Model Results for Emergency Department Use, Lung Cancer Cohort

Unknown Cancer Stage*Post-Diagnosis Period **Bold** values indicate statistically significant effect at α=0.05

Unknown Cancer Stage*Peri-Diagnosis Period

Interactions of Cancer Stage and Time Period

(ref = Stage 4, Pre-Diagnosis Period)

Stage 3

Unknown Stage

Surgical Intervention

Chemotherapy Treatment

Radiation Therapy Treatment

Stage 1*Peri-Diagnosis Period

Stage 1*Post-Diagnosis Period

Stage 2*Peri-Diagnosis Period

Stage 2*Post-Diagnosis Period

Stage 3*Peri-Diagnosis Period

Stage 3*Post-Diagnosis Period

0.2968

0.9260

0.2167

0.4466

< 0.0001

p-value

<0.0001

<0.0001

0.0383

0.3324

0.0127

0.4761

0.4382

0.6940

Appendix Table 3.7: Continued

Comparison Tests	Relative Rate (95%	m voluo
Comparison Tests	Confidence Interval)	p-value
Cancer Stages 3-4 vs. 1-2		
Overall	1.34 (1.10, 1.62)	0.0034
Pre-Diagnosis Period	0.83 (0.61, 1.14)	0.2609
Peri-Diagnosis Period	1.95 (1.47, 2.58)	<0.0001
Post-Diagnosis Period	1.47 (1.16, 1.86)	0.0014
Cancer Stages 1-2: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	1.97 (1.34, 2.91)	0.0006
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.51 (1.04, 2.20)	0.0308
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.77 (0.57, 1.03)	0.0761
Cancer Stages 3-4: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	4.60 (3.77, 5.62)	<0.0001
Post-Diagnosis Period vs. Pre-Diagnosis Period	2.66 (1.97, 3.60)	<0.0001
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.58 (0.48, 0.70)	<0.0001

Model Covariates	Relative Rate (95%	n value
Model Covariates	Confidence Interval)	p-value
Intercept	0.00 (0.00, 0.01)	<0.0001
Month of Diagnosis	0.99 (0.98, 1.00)	0.2732
Time Period (ref = Pre-Diagnosis)		
Peri-Diagnosis Period	2.71 (1.89, 3.88)	<0.0001
Post-Diagnosis Period	1.22 (0.84, 1.77)	0.3043
Age	1.02 (1.02, 1.03)	< 0.0001
Income Quintile (ref = Q5 (highest))		
Q1 (lowest)	1.40 (1.17, 1.68)	0.0002
Q2	1.08 (0.90, 1.30)	0.4030
Q3	1.09 (0.91, 1.32)	0.3551
Q4	1.12 (0.94, 1.35)	0.2104
Income Unknown	0.95 (0.73, 1.24)	0.6904
Charlson Index	1.16 (1.11, 1.20)	<0.0001
Number of Inpatient Hospitalizations	5.00 (4.49, 5.58)	< 0.0001
Majority of Care	1.01 (0.90, 1.13)	0.8708
Number of Ambulatory Physician Visits	1.35 (1.31, 1.40)	<0.0001
Number of Prescription Drug Dispensations	1.02 (1.01, 1.03)	<0.0001
Cancer Stage (ref = Stage 4)		
Stage 1	0.66 (0.35, 1.26)	0.2067
Stage 2	0.70 (0.51, 0.95)	0.0229
Stage 3	0.58 (0.36, 0.94)	0.0283
Unknown Stage	0.49 (0.19, 1.24)	0.1318
Chemotherapy Treatment	1.04 (0.76, 1.43)	0.8038
Hormone Therapy Treatment	1.18 (1.03, 1.36)	0.0196
Radiation Therapy Treatment	1.01 (0.88, 1.14)	0.9360
Surgical Intervention	1.41 (1.24, 1.59)	< 0.0001
Interactions of Cancer Stage and Time Period	Relative Rate (95%	p-value
(ref = Stage 4, Pre-Diagnosis Period)	Confidence Interval)	
Stage 1*Peri-Diagnosis Period	0.67 (0.26, 1.72)	0.4045
Stage 1*Post-Diagnosis Period	1.45 (0.69, 3.06)	0.3291
Stage 2*Peri-Diagnosis Period	0.59 (0.39, 0.88)	0.0102
Stage 2*Post-Diagnosis Period	0.97 (0.68, 1.39)	0.8845
Stage 3*Peri-Diagnosis Period	0.67 (0.33, 1.36)	0.2646
Stage 3*Post-Diagnosis Period	0.93 (0.53, 1.64)	0.8045
Unknown Cancer Stage*Peri-Diagnosis Period	0.47 (0.15, 1.52)	0.2094
		I

Appendix Table 3.8: Poisson Regression Model Results for Emergency Department Use, Prostate Cancer Cohort Winning residents, 2007/08-2010/11

Bold values indicate statistically significant effect at α =0.05

Unknown Cancer Stage*Post-Diagnosis Period

0.8148

1.14 (0.39, 3.36)

Appendix Table 3.8: Continued

Comparison Tasta	Relative Rate (95%	m valua
Comparison Tests	Confidence Interval)	p-value
Cancer Stages 3-4 vs. 1-2		
Overall	1.14 (0.85, 1.54)	0.3769
Pre-Diagnosis Period	1.12 (0.73, 1.73)	0.6019
Peri-Diagnosis Period	1.46 (0.86, 2.49)	0.1629
Post-Diagnosis Period	0.91 (0.66, 1.25)	0.5673
Cancer Stages 1-2: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	1.70 (1.07, 2.71)	0.0261
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.45 (0.95, 2.20)	0.0853
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.85 (0.56, 1.29)	0.4495
Cancer Stages 3-4: Comparison of Time Periods		
Peri-Diagnosis Period vs. Pre-Diagnosis Period	2.21 (1.41, 3.47)	0.0006
Post-Diagnosis Period vs. Pre-Diagnosis Period	1.17 (0.78, 1.76)	0.4391
Post-Diagnosis Period vs. Peri-Diagnosis Period	0.53 (0.36, 0.78)	0.0012

Regression Model Results for Hours of Emergency Department Use for Cancer Cohorts

Appendix Table 3.9: Unadjusted Poisson Regression Model Results for Emergency Department Use During Office Hour and Non-Office Hour Time Segments for Cancer Cohort and Matched Cancer-Free Cohort, Stratified by Cancer Site

Winnipeg residents, 2007/08-2010/11					
Cancer Site	Compa	rison of Cohorts:	Relative Rate (95%	p-value	
Cancer Site	Cancer Cohort vs.	Matched Cancer-Free Cohort	Confidence Interval)	p-value	
	Pre-Diagnosis Period	Office Hours	1.29 (1.04, 1.58)	0.0178	
		Non-Office Hours	1.02 (0.85, 1.24)	0.8101	
Breast	Peri-Diagnosis Period	Office Hours	2.98 (2.08, 4.27)	<0.0001	
Diedst		Non-Office Hours	2.08 (1.50, 2.90)	<0.0001	
	Post-Diagnosis Period	Office Hours	2.00 (1.77, 2.25)	<0.0001	
		Non-Office Hours	2.08 (1.86, 2.32)	<0.0001	
	Pre-Diagnosis Period	Office Hours	1.44 (1.22, 1.70)	<0.0001	
		Non-Office Hours	1.26 (1.07, 1.48)	0.0056	
Colorectal	Peri-Diagnosis Period	Office Hours	6.79 (5.09, 9.06)	<0.0001	
Colorectar		Non-Office Hours	6.01 (4.63, 7.80)	<0.0001	
	Post-Diagnosis Period	Office Hours	2.01 (1.81, 2.22)	<0.0001	
		Non-Office Hours	1.94 (1.76, 2.14)	<0.0001	
	Pre-Diagnosis Period	Office Hours	1.50 (1.28, 1.76)	<0.0001	
		Non-Office Hours	1.41 (1.21, 1.64)	<0.0001	
Lung	Peri-Diagnosis Period	Office Hours	12.65 (9.43, 16.98)	<0.0001	
Lung		Non-Office Hours	11.30 (8.38, 15.24)	<0.0001	
	Post-Diagnosis Period	Office Hours	3.25 (2.93, 3.62)	<0.0001	
		Non-Office Hours	3.20 (2.88, 3.55)	<0.0001	
	Pre-Diagnosis Period	Office Hours	1.12 (0.91, 1.39)	0.2798	
		Non-Office Hours	1.33 (1.09, 1.62)	0.0056	
Prostate	Peri-Diagnosis Period	Office Hours	12.13 (6.15, 23.94)	<0.0001	
FIOState		Non-Office Hours	6.77 (4.28, 10.71)	<0.0001	
	Post-Diagnosis Period	Office Hours	1.46 (1.28, 1.66)	<0.0001	
		Non-Office Hours	1.57 (1.38, 1.79)	<0.0001	
Cancer Site	-	n of Time Segments:	Relative Rate (95%	p-value	
		Hours vs. Office Hours	Confidence Interval)	-	
	Pre-Diagnosis Period	Cancer Cohort		0.4075	
	The Diagnosis Feriod		1.08 (0.90, 1.31)		
	J	Matched Cancer-Free Cohort	1.36 (1.11, 1.67)	0.0032	
Breast	Peri-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18)	0.0032 0.4655	
Breast	Peri-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96)	0.0032 0.4655 0.2122	
Breast	J	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29)	0.0032 0.4655 0.2122 0.0012	
Breast	Peri-Diagnosis Period Post-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29)	0.0032 0.4655 0.2122 0.0012 0.0777	
Breast	Peri-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876	
Breast	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962	
Breast	Peri-Diagnosis Period Post-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877	
	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877 0.2343	
	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228	
	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171	
	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310	
	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291	
Colorectal	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272	
	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99) 0.98 (0.65, 1.46)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272 0.9183	
Colorectal	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99) 0.98 (0.65, 1.46) 1.03 (0.94, 1.14)	0.0032 0.4655 0.2122 0.0012 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272 0.9183 0.4966	
Colorectal	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99) 0.98 (0.65, 1.46) 1.03 (0.94, 1.14) 1.05 (0.94, 1.18)	0.0032 0.4655 0.2122 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272 0.9183 0.4966 0.3976	
Colorectal	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99) 0.98 (0.65, 1.46) 1.03 (0.94, 1.14) 1.05 (0.94, 1.18) 1.23 (1.01, 1.50)	0.0032 0.4655 0.2122 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272 0.9183 0.4966 0.3976 0.0370	
Colorectal	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99) 0.98 (0.65, 1.46) 1.03 (0.94, 1.14) 1.05 (0.94, 1.18) 1.23 (1.01, 1.50) 1.04 (0.84, 1.30)	0.0032 0.4655 0.2122 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272 0.9183 0.4966 0.3976 0.0370 0.6996	
Colorectal	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Cancer Cohort Cancer Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99) 0.98 (0.65, 1.46) 1.03 (0.94, 1.14) 1.05 (0.94, 1.18) 1.23 (1.01, 1.50) 1.04 (0.84, 1.30) 1.30 (1.02, 1.67)	0.0032 0.4655 0.2122 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272 0.9183 0.4966 0.3976 0.0370 0.6996 0.0378	
Colorectal	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Pre-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Cancer Cohort Matched Cancer-Free Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99) 0.98 (0.65, 1.46) 1.03 (0.94, 1.14) 1.05 (0.94, 1.18) 1.23 (1.01, 1.50) 1.04 (0.84, 1.30) 1.30 (1.02, 1.67) 2.33 (1.07, 5.09)	0.0032 0.4655 0.2122 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272 0.9183 0.4966 0.3976 0.0370 0.6996 0.0378 0.0334	
Colorectal	Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period Pre-Diagnosis Period Peri-Diagnosis Period Post-Diagnosis Period	Matched Cancer-Free Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Cancer Cohort Cancer Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort Cancer Cohort Matched Cancer-Free Cohort Cancer Cohort	1.36 (1.11, 1.67) 0.91 (0.70, 1.18) 1.30 (0.86, 1.96) 1.17 (1.06, 1.29) 1.13 (0.99, 1.29) 0.98 (0.84, 1.14) 1.12 (0.94, 1.34) 1.10 (0.95, 1.27) 1.25 (0.87, 1.79) 1.11 (1.01, 1.21) 1.15 (1.02, 1.28) 1.07 (0.93, 1.24) 1.14 (0.96, 1.35) 0.87 (0.78, 0.99) 0.98 (0.65, 1.46) 1.03 (0.94, 1.14) 1.05 (0.94, 1.18) 1.23 (1.01, 1.50) 1.04 (0.84, 1.30) 1.30 (1.02, 1.67)	0.0032 0.4655 0.2122 0.0777 0.7876 0.1962 0.1877 0.2343 0.0228 0.0171 0.3310 0.1291 0.0272 0.9183 0.4966 0.3976 0.0370 0.6996 0.0378	

APPENDIX 4: COX PROPORTIONAL HAZARDS REGRESSION MODEL RESULTS FOR DEATH AFTER CANCER DIAGNOSIS

Appendix Table 4.1: Results for Cox Proportional Hazards Regression Model for Death after Breast Cancer Diagnosis

Winnipeg residents, 2007/08-2011/12

Madel Consister	Hazard Ratio (95%		
Model Covariates	Confidence Interval)	p-value	
Age (deciles)	1.33 (1.21, 1.45)	<0.0001	
Sex (ref = Female)	0.53 (0.12, 2.30)	0.3961	
Income Quintile (ref = Q5 (highest))			
Q1 (lowest)	1.05 (0.72, 1.54)	0.8085	
Q2	0.75 (0.50, 1.13)	0.1645	
Q3	0.73 (0.48, 1.10)	0.1356	
Q4	0.80 (0.52, 1.24)	0.3172	
Income Unknown	1.29 (0.81, 2.06)	0.2865	
Cancer Stage (ref = Stage 1)			
Stage 2	2.19 (1.48, 3.25)	<0.0001	
Stage 3	6.68 (4.44, 10.04)	<0.0001	
Stage 4	27.45 (18.41, 40.91)	<0.0001	
Unknown Stage	13.25 (7.73, 22.71)	<0.0001	
Weighted Cancer-free Charlson Comorbidity Score	1.22 (1.08, 1.39)	0.0020	
Number of Emergency Department Visits			
Pre-diagnosis (1 year before diagnosis)	0.98 (0.93, 1.04)	0.5425	
Post-diagnosis (time-varying, every six months)	1.27 (1.18, 1.37)	<0.0001	
Number of Inpatient Hospitalizations			
Pre-diagnosis (1 year before diagnosis)	0.93 (0.85, 1.02)	0.1293	
Post-diagnosis (time-varying, every six months)	3.52 (3.06, 4.06)	<0.0001	
Number of Ambulatory Physician Visits			
Pre-diagnosis (1 year before diagnosis)	1.02 (1.00, 1.04)	0.0654	
Post-diagnosis (time-varying, every six months)	0.75 (0.71, 0.78)	<0.0001	
Number of Drug Prescription Dispensations (scaled in groups of 10)			
Pre-diagnosis (1 year before diagnosis)	1.06 (1.04, 1.09)	<0.0001	
Post-diagnosis (time-varying, every six months)	0.90 (0.85, 0.95)	0.0002	

Appendix Table 4.2: Results for Cox Proportional Hazards Regression Model for Death after Colorectal Cancer Diagnosis

Winnipeg residents, 2007/08-2011/12

Model Covariates	Hazard Ratio (95%		
iviodel Covariates	Confidence Interval)	p-value	
Age (deciles)	1.41 (1.32, 1.51)	< 0.0001	
Sex (ref = Female)	1.08 (0.92, 1.27)	0.3304	
Income Quintile (ref = Q5 (highest))			
Q1 (lowest)	1.01 (0.78, 1.31)	0.9399	
Q2	1.13 (0.86, 1.48)	0.3958	
Q3	1.03 (0.79, 1.35)	0.8290	
Q4	0.93 (0.69, 1.25)	0.6307	
Income Unknown	1.49 (1.04, 2.13)	0.0283	
Cancer Stage (ref = Stage 1)			
Stage 2	1.41 (0.99, 2.02)	0.0584	
Stage 3	3.03 (2.16, 4.25)	< 0.0001	
Stage 4	13.19 (9.47, 18.37)	< 0.0001	
Unknown Stage	3.87 (2.61, 5.73)	<0.0001	
Weighted Cancer-free Charlson Comorbidity Score	1.22 (1.08, 1.39)	0.0020	
Number of Emergency Department Visits			
Pre-diagnosis (1 year before diagnosis)	1.04 (0.99, 1.10)	0.1182	
Post-diagnosis (time-varying, every six months)	1.11 (1.04, 1.18)	0.0012	
Number of Inpatient Hospitalizations			
Pre-diagnosis (1 year before diagnosis)	0.90 (0.77, 1.06)	0.2073	
Post-diagnosis (time-varying, every six months)	1.78 (1.62, 1.95)	<0.0001	
Number of Ambulatory Physician Visits			
Pre-diagnosis (1 year before diagnosis)	1.03 (1.01, 1.04)	0.0002	
Post-diagnosis (time-varying, every six months)	0.73 (0.71, 0.75)	< 0.0001	
Number of Drug Prescription Dispensations (scaled in groups of 10)			
Pre-diagnosis (1 year before diagnosis)	1.02 (1.01, 1.04)	0.0004	
Post-diagnosis (time-varying, every six months)	0.99 (0.95, 1.03)	0.5358	

Madel Consister	Hazard Ratio (95%	p-value	
Model Covariates	Confidence Interval)		
Age (deciles)	1.07 (1.02, 1.12)	0.0041	
Sex (ref = Female)	1.24 (1.11, 1.38)	<0.0001	
Income Quintile (ref = Q5 (highest))			
Q1 (lowest)	1.08 (0.89, 1.31)	0.4664	
Q2	0.99 (0.81, 1.22)	0.9246	
Q3	1.08 (0.87, 1.33)	0.4848	
Q4	1.02 (0.82, 1.26)	0.8916	
Income Unknown	1.27 (0.91, 1.78)	0.1542	
Cancer Stage (ref = Stage 1)			
Stage 2	2.22 (1.61, 3.06)	< 0.0001	
Stage 3	4.37 (3.53, 5.42)	< 0.0001	
Stage 4	7.06 (5.77, 8.63)	< 0.0001	
Unknown Stage	3.31 (2.35, 4.65)	< 0.0001	
Weighted Cancer-free Charlson Comorbidity Score	1.11 (1.05, 1.17)	0.0003	
Number of Emergency Department Visits			
Pre-diagnosis (1 year before diagnosis)	1.04 (1.00, 1.08)	0.0713	
Post-diagnosis (time-varying, every six months)	1.10 (1.06, 1.14)	< 0.0001	
Number of Inpatient Hospitalizations			
Pre-diagnosis (1 year before diagnosis)	0.94 (0.85, 1.04)	0.2231	
Post-diagnosis (time-varying, every six months)	1.44 (1.35, 1.54)	<0.0001	
Number of Ambulatory Physician Visits			
Pre-diagnosis (1 year before diagnosis)	1.02 (1.01, 1.03)	0.0002	
Post-diagnosis (time-varying, every six months)	0.78 (0.77, 0.80)	<0.0001	
Number of Drug Prescription Dispensations (scaled in groups of 10)			
Pre-diagnosis (1 year before diagnosis)	1.03 (1.02, 1.04)	< 0.0001	
Post-diagnosis (time-varying, every six months)	0.86 (0.83, 0.90)	< 0.0001	

Appendix Table 4.3: Results for Cox Proportional Hazards Regression Model for Death after Lung Cancer Diagnosis

Winnipeg residents, 2007/08-2011/12

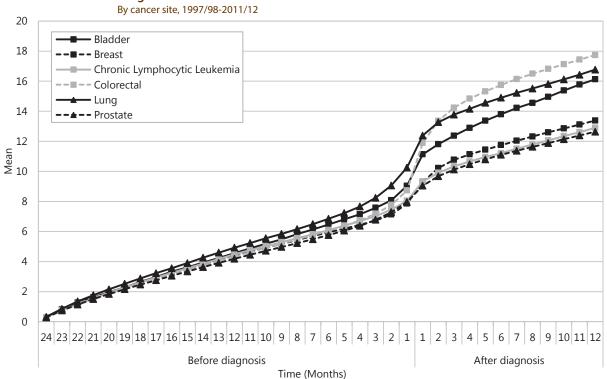
Appendix Table 4.4: Results for Cox Proportional Hazards Regression Model for Death after Prostate Cancer Diagnosis

Winnipeg residents, 2007/08-2011/12

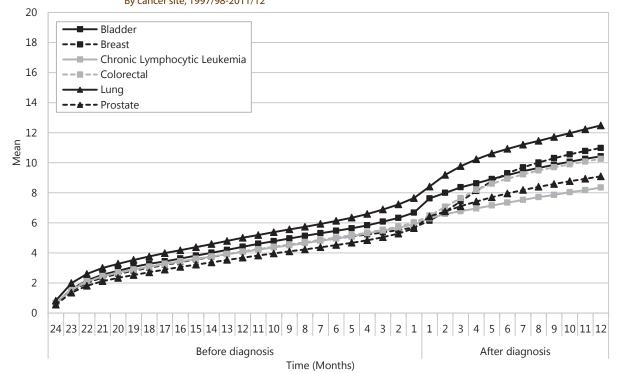
Model Covariates	Hazard Ratio (95%		
Woder Covariates	Confidence Interval)	p-value	
Age (deciles)	1.06 (1.04, 1.07)	<0.0001	
Income Quintile (ref = Q5 (highest))			
Q1 (lowest)	0.84 (0.48, 1.47)	0.5354	
Q2	1.24 (0.73, 2.10)	0.4323	
Q3	1.36 (0.80, 2.34)	0.2601	
Q4	1.06 (0.59, 1.90)	0.8426	
Income Unknown	2.88 (1.57, 5.26)	0.0006	
Cancer Stage (ref = Stage 1)			
Stage 2	1.20 (0.37, 3.86)	0.7591	
Stage 3	1.03 (0.25, 4.15)	0.9716	
Stage 4	9.96 (3.09, 32.09)	0.0001	
Unknown Stage	5.01 (1.40, 17.89)	0.0132	
Weighted Cancer-free Charlson Comorbidity Score	1.09 (0.95, 1.25)	0.2050	
Number of Emergency Department Visits			
Pre-diagnosis (1 year before diagnosis)	1.12 (1.02, 1.24)	0.0178	
Post-diagnosis (time-varying, every six months)	1.02 (0.91, 1.16)	0.7018	
Number of Inpatient Hospitalizations			
Pre-diagnosis (1 year before diagnosis)	1.00 (0.74, 1.34)	0.9714	
Post-diagnosis (time-varying, every six months)	2.81 (2.36, 3.34)	<0.0001	
Number of Ambulatory Physician Visits			
Pre-diagnosis (1 year before diagnosis)	1.05 (1.02, 1.08)	0.0006	
Post-diagnosis (time-varying, every six months)	0.83 (0.78, 0.87)	<0.0001	
Number of Drug Prescription Dispensations (scaled in groups of 10)			
Pre-diagnosis (1 year before diagnosis)	1.05 (1.01, 1.09)	0.0159	
Post-diagnosis (time-varying, every six months)	0.91 (0.84, 0.99)	0.0221	
Bold values indicate a significant effect at $\alpha = 0.05$			

APPENDIX 5: CUMULATIVE MEAN NUMBER OF DIAGNOSES AND DRUG DISPENSATIONS IN THE CANCER COHORT

Appendix Figure 5.1: Cumulative Mean Number of New Diagnoses for the Cancer Cohort, Including Cancer Diagnoses







Appendix Figure 5.2: Cumulative Mean Number of New Prescription Drugs Dispensations for the Cancer Cohort, Including Cancer-Related Drugs By cancer site, 1997/98-2011/12

APPENDIX 6: RECLASSIFICATION STATISTICS FOR LOGISTIC MODELS PREDICTING MORTALITY, HEALTH OUTCOMES, AND HEALTHCARE USE

Predictive Models for All-Cause Mortality and In-Hospital Mortality

By cancer site, 1	997/98-2011/12			
Models	Integrated Discrimination Improvement (95% Confidence Interval)	Net Reclassification Improvement (95% Confidence Interval)	% of Events Correctly Reclassified	% of Non- Events Correctly Reclassified
Bladder				
No. of diagnoses	0.007 (0.001, 0.012)	0.131 (0.012, 0.250)	-12.7	25.8
No. of drugs	0.002 (-0.001, 0.006)	0.121 (0.002, 0.241)	-11.1	23.2
No. of ADGs®	0.002 (-0.001, 0.005)	0.094 (-0.027, 0.214)	-6.3	15.7
Resource Utilization Bands	0.006 (0.001, 0.011)	0.251 (0.132, 0.371)	-4.2	29.3
Chronic Disease Score	0.000 (0.000, 0.000)	0.065 (-0.055, 0.185)	-9.0	15.5
Charlson Index	0.016 (0.007, 0.024)	0.142 (0.021, 0.262)	9.0	5.2
Elixhauser Index	0.071 (0.053, 0.089)	0.453 (0.340, 0.565)	-16.9	62.2
Breast				
No. of diagnoses	0.002 (-0.001, 0.006)	0.144 (0.051, 0.237)	-11.0	25.4
No. of drugs	0.004 (-0.001, 0.008)	0.213 (0.120, 0.306)	-8.4	29.7
No. of ADGs®	0.001 (-0.002, 0.004)	0.121 (0.028, 0.215)	-5.8	18.0
Resource Utilization Bands	0.002 (-0.001, 0.006)	0.162 (0.069, 0.256)	0.6	15.6
Chronic Disease Score	0.003 (-0.001, 0.008)	0.246 (0.153, 0.340)	-4.5	29.1
Charlson Index	0.017 (0.008, 0.027)	0.383 (0.290, 0.476)	2.8	35.5
Elixhauser Index	0.019 (0.010, 0.027)	0.546 (0.454, 0.639)	14.9	39.7
Chronic Lymphocytic Leukemia				
No. of diagnoses	0.018 (0.002, 0.033)	0.317 (0.067, 0.567)	0.0	31.7
No. of drugs	0.008 (-0.004, 0.019)	0.310 (0.060, 0.560)	-3.0	34.0
No. of ADGs®	0.015 (0.001, 0.028)	0.183 (-0.068, 0.434)	-3.0	21.3
Resource Utilization Bands	0.035 (0.015, 0.055)	0.650 (0.407, 0.893)	24.2	40.8
Chronic Disease Score	0.008 (-0.003, 0.019)	0.228 (-0.022, 0.478)	-6.1	28.8
Charlson	0.006 (-0.003, 0.015)	0.184 (-0.067, 0.434)	6.1	12.3
Elixhauser	0.115 (0.065, 0.164)	0.688 (0.443, 0.934)	15.2	53.7
Colorectal				
No. of diagnoses	0.003 (0.002, 0.005)	0.134 (0.082, 0.186)	-10.2	23.6
No. of drugs	0.001 (0.000, 0.002)	0.125 (0.073, 0.177)	-8.6	21.1
No. of ADGs	0.004 (0.002, 0.006)	0.171 (0.119, 0.223)	-1.3	18.4
Resource Utilization Bands	0.007 (0.004, 0.009)	0.307 (0.255, 0.358)	-5.4	36.1
CDS	0.001 (0.000, 0.002)	0.107 (0.054, 0.159)	-6.9	17.6
Charlson Index	0.013 (0.010, 0.017)	0.174 (0.122, 0.226)	1.1	16.3
Elixhauser Index	0.023 (0.018, 0.027)	0.304 (0.252, 0.356)	-1.4	31.9
Lung				
No. of diagnoses	0.000 (0.000, 0.001)	0.055 (0.012, 0.098)	-12.9	18.4
No. of drugs	0.000 (0.000, 0.000)	0.001 (-0.042, 0.045)	-13.4	13.5
No. of ADGs®	0.000 (0.000, 0.000)	-0.012 (-0.056, 0.031)	7.4	-8.6
Resource Utilization Bands	0.000 (0.000, 0.001)	0.058 (0.015, 0.102)	-3.7	9.5
Chronic Disease Score	0.000 (0.000, 0.001)	0.059 (0.016, 0.103)	-6.2	12.1
Charlson Index	0.003 (0.002, 0.005)	0.029 (-0.014, 0.071)	-19.1	22.0
Elixhauser Index	0.013 (0.010, 0.015)	0.151 (0.111, 0.192)	-23.8	39.0
Prostate				
No. of diagnoses	0.016 (0.009, 0.023)	0.311 (0.217, 0.405)	-2.9	34.0
No. of drugs	0.011 (0.006, 0.016)	0.323 (0.228, 0.417)	2.0	30.3
No. of ADGs®	0.010 (0.005, 0.016)	0.304 (0.210, 0.399)	4.6	25.8
Resource Utilization Bands	0.009 (0.004, 0.013)	0.479 (0.385, 0.573)	3.7	44.1
Chronic Disease Score	0.011 (0.006, 0.016)	0.300 (0.205, 0.395)	2.4	27.6
Charlson Index	0.024 (0.015, 0.033)	0.287 (0.193, 0.382)	4.2	24.6
Elixhauser Index Bold values indicate a statistically si	0.049 (0.036, 0.062)	0.477 (0.384, 0.570)	-11.2	58.9

Appendix Table 6.1: Reclassification Statistics for Logistic Regression Models Predicting All-Cause Mortality

By cancer site, 1997/98-2011/12

Appendix Table 6.2: Reclassification Statistics for Logistic Regression Models Predicting In-Hospital Mortality

By cancer	site,	1997	/98-20)11	/12
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	Integrated			% of Non-
	Discrimination	Net Reclassification	% of Events	Events
Models		Improvement (95%	Correctly	
	Improvement (95%	Confidence Interval)	Reclassified	Correctly
	Confidence Interval)	,		Reclassified
Bladder				
No. of diagnoses	0.002 (-0.002, 0.005)	0.128 (-0.005, 0.262)	-12.3	25.1
No. of drugs	0.001 (-0.002, 0.004)	0.083 (-0.050, 0.217)	-13.0	21.3
No. of ADGs®	0.001 (-0.002, 0.004)	0.156 (0.022, 0.291)	-1.1	16.8
Resource Utilization Bands	0.002 (-0.002, 0.005)	0.209 (0.075, 0.343)	-4.8	25.7
Chronic Disease Score	0.000 (0.000, 0.000)	0.048 (-0.086, 0.183)	-10.0	14.9
Charlson Index	0.002 (-0.002, 0.006)	0.079 (-0.057, 0.214)	4.8	3.0
Elixhauser Index	0.047 (0.030, 0.065)	0.397 (0.266, 0.527)	-12.3	51.9
Breast			1	
No. of diagnoses	0.001 (-0.002, 0.005)	0.055 (-0.048, 0.159)	-17.1	22.7
No. of drugs	0.001 (-0.001, 0.003)	0.073 (-0.030, 0.177)	-16.6	23.9
No. of ADGs®	0.001 (-0.002, 0.003)	0.110 (0.005, 0.215)	-6.1	17.1
Resource Utilization Bands	0.002 (-0.001, 0.004)	0.077 (-0.029, 0.182)	-4.4	12.1
Chronic Disease Score	0.002 (-0.001, 0.004)	0.157 (0.052, 0.262)	-7.7	23.4
Charlson Index	0.014 (0.005, 0.023)	0.258 (0.153, 0.363)	-5.0	30.8
Elixhauser Index	0.027 (0.015, 0.038)	0.445 (0.340, 0.550)	3.9	40.6
Chronic Lymphocytic Leukemia			10	24.2
No. of diagnoses	0.019 (0.001, 0.037)	0.383 (0.099, 0.668)	4.0	34.3
No. of drugs	0.006 (-0.005, 0.017)	0.211 (-0.072, 0.494)	-12.0	33.1
No. of ADGs®	0.010 (-0.002, 0.023)	0.212 (-0.074, 0.497)	0.0	21.2
Resource Utilization Bands	0.011 (-0.002, 0.023)	0.411 (0.127, 0.695)	8.0	33.1
Chronic Disease Score	0.008 (-0.004, 0.021)	0.246 (-0.038, 0.530)	-8.0	32.6
Charlson Index	0.006 (-0.006, 0.018)	0.243 (-0.041, 0.528)	8.0	16.3
Elixhauser Index Colorectal	0.046 (0.015, 0.076)	0.489 (0.206, 0.773)	8.0	40.9
No. of diagnoses	0.002 (0.000, 0.004)	0.106 (0.048, 0.165)	-11.6	22.3
No. of drugs	0.001 (0.000, 0.001)	0.118 (0.059, 0.177)	-7.6	19.4
No. of ADGs®	0.003 (0.001, 0.004)	0.141 (0.082, 0.201)	-2.4	19.4
Resource Utilization Bands	0.004 (0.002, 0.007)	0.296 (0.238, 0.355)	-4.4	34.1
Chronic Disease Score	0.001 (0.000, 0.001)	0.074 (0.015, 0.133)	-8.7	16.1
Charlson Index	0.008 (0.004, 0.011)	0.097 (0.038, 0.156)	-6.1	15.8
Elixhauser Index	0.017 (0.012, 0.021)	0.250 (0.191, 0.309)	-3.4	28.4
Lung		0.230 (0.131, 0.303)	5.4	20.4
No. of diagnoses	0.000 (0.000, 0.000)	-0.004 (-0.046, 0.038)	15.1	-15.5
No. of drugs	0.000 (0.000, 0.001)	0.035 (-0.007, 0.077)	15.2	-11.6
No. of ADGs®	0.000 (0.000, 0.000)	0.017 (-0.026, 0.059)	8.3	-6.6
Resource Utilization Bands	0.000 (0.000, 0.001)	0.066 (0.024, 0.109)	-2.3	8.9
Chronic Disease Score	0.000 (0.000, 0.000)	0.010 (-0.032, 0.053)	9.2	-8.2
Charlson Index	0.001 (0.000, 0.001)	-0.018 (-0.060, 0.024)	-21.6	19.8
Elixhauser Index	0.008 (0.006, 0.010)	0.125 (0.083, 0.168)	-5.3	17.9
Prostate				
No. of diagnoses	0.008 (0.004, 0.013)	0.273 (0.166, 0.380)	-2.6	29.9
No. of drugs	0.006 (0.003, 0.010)	0.268 (0.161, 0.376)	-0.3	27.1
No. of ADGs®	0.009 (0.004, 0.013)	0.302 (0.195, 0.409)	5.4	24.7
Resource Utilization Bands	0.006 (0.002, 0.009)	0.457 (0.350, 0.564)	4.3	41.4
Chronic Disease Score	0.005 (0.002, 0.008)	0.220 (0.113, 0.327)	-1.4	23.4
Charlson Index	0.017 (0.010, 0.025)	0.285 (0.178, 0.392)	4.9	23.6
Elixhauser Index	0.035 (0.024, 0.046)	0.400 (0.294, 0.506)	-10.0	50.0

Predictive Models for Healthcare Use

Appendix Table 6.3: Reclassification Statistics for Logistic Regression Models Predicting Incident

Hospitalization

By cancer site, 1997/98-2011/12

	Integrated	· · ·		% of Non-
	-	Net Reclassification	% of Events	
Models	Discrimination	Improvement (95%	Correctly	Events
	Improvement (95%	Confidence Interval)	Reclassified	Correctly
	Confidence Interval)	confidence intervalj	Reclassified	Reclassified
Bladder			•	•
No. of diagnoses	0.008 (0.002, 0.014)	0.129 (-0.015, 0.273)	-9.4	22.4
No. of drugs	0.004 (0.000, 0.009)	0.051 (-0.094, 0.196)	-11.8	16.9
No. of ADGs®	0.005 (0.000, 0.010)	0.148 (0.003, 0.294)	-2.0	16.9
Resource Utilization Bands	0.003 (-0.001, 0.008)	0.104 (-0.034, 0.243)	-25.3	35.7
Chronic Disease Score	0.001 (-0.001, 0.003)	-0.025 (-0.171, 0.120)	-13.1	10.6
Charlson Index	0.005 (0.000, 0.010)	0.129 (-0.017, 0.276)	2.4	10.6
Elixhauser Index	0.026 (0.016, 0.037)	0.156 (0.013, 0.300)	-9.1	24.7
Breast				
No. of diagnoses	0.002 (0.001, 0.003)	0.094 (0.043, 0.144)	-13.9	23.3
No. of drugs	0.001 (0.000, 0.001)	0.057 (0.007, 0.108)	-16.2	21.9
No. of ADGs®	0.002 (0.001, 0.004)	0.096 (0.045, 0.147)	-7.1	16.6
Resource Utilization Bands	0.002 (0.001, 0.003)	0.075 (0.024, 0.127)	5.6	2.0
Chronic Disease Score	0.000 (0.000, 0.001)	0.032 (-0.019, 0.083)	-15.5	18.8
Charlson Index	0.005 (0.003, 0.007)	0.149 (0.100, 0.199)	-15.5	30.4
Elixhauser Index	0.014 (0.011, 0.017)	0.211 (0.162, 0.261)	-11.2	32.3
Chronic Lymphocytic Leukemia			1	1
No. of diagnoses	0.008 (-0.001, 0.018)	0.245 (0.076, 0.414)	-6.0	30.5
No. of drugs	0.021 (0.007, 0.036)	0.277 (0.108, 0.446)	-4.8	32.5
No. of ADGs®	0.006 (-0.002, 0.014)	0.214 (0.044, 0.384)	1.2	20.2
Resource Utilization Bands	0.004 (-0.003, 0.010)	0.084 (-0.083, 0.251)	-19.0	27.5
Chronic Disease Score	0.017 (0.004, 0.030)	0.244 (0.075, 0.414)	-2.4	26.8
Charlson Index	0.006 (-0.002, 0.014)	0.088 (-0.083, 0.258)	-7.1	15.9
Elixhauser Index	0.068 (0.044, 0.091)	0.541 (0.374, 0.708)	10.7	43.4
Colorectal			0.7	20.0
No. of diagnoses	0.007 (0.003, 0.011)	0.265 (0.161, 0.370)	-2.7	29.2
No. of drugs	0.004 (0.002, 0.007)	0.187 (0.082, 0.292)	-7.6	26.3
No. of ADGs®	0.006 (0.002, 0.009)	0.250 (0.144, 0.357)	2.2	22.8
Resource Utilization Bands	0.010 (0.006, 0.015)	0.321 (0.222, 0.421)	-10.0	42.1
Chronic Disease Score	0.003 (0.001, 0.006)	0.204 (0.099, 0.310)	-5.9	26.3
Charlson Index	0.008 (0.004, 0.013)	0.415 (0.319, 0.512)	-6.4	48.0
Elixhauser Index	0.033 (0.025, 0.041)	0.550 (0.457, 0.644)	1.8	53.2
Lung No. of diagnoses	0.010 (0.006 0.014)	0 195 (0 107 0 264)	E C	2/1
No. of diagnoses	0.010 (0.006, 0.014) 0.007 (0.004, 0.010)	0.185 (0.107, 0.264)	-5.6 -7.3	24.1 17.0
		0.097 (0.018, 0.177)		
No. of ADGs® Resource Utilization Bands	0.006 (0.003, 0.009) 0.002 (0.000, 0.004)	0.143 (0.064, 0.223)	0.1 18.5	14.2 -0.5
Chronic Disease Score		0.180 (0.100, 0.260)		
Chronic Disease Score Charlson Index	0.006 (0.003, 0.009)	0.174 (0.094, 0.253)	-2.2	19.5 19.0
Elixhauser Index	0.004 (0.001, 0.007)	0.172 (0.093, 0.251)	-1.9	36.5
Prostate	0.021 (0.015, 0.027)	0.297 (0.221, 0.374)	-6.8	30.5
No. of diagnoses	0.002 (0.001, 0.003)	0.077 (0.030, 0.123)	-14.8	22.4
No. of drugs	0.002 (0.001, 0.003)	0.051 (0.004, 0.097)	-14.8	19.0
No. of ADGs®	0.001 (0.000, 0.002)	0.031 (0.004, 0.037)	-15.9	19.0
Resource Utilization Bands	0.001 (0.001, 0.002)	0.204 (0.160, 0.249)	-0.4	43.5
Chronic Disease Score	0.002 (0.001, 0.003)	0.077 (0.031, 0.124)	-10.3	18.0
Charlson Index	0.002 (0.001, 0.003)	0.067 (0.020, 0.114)	-9.6	16.3
Elixhauser Index	0.013 (0.011, 0.016)	0.354 (0.310, 0.399)	-9.8	45.2
Bold values indicate a statistically sid				1.3.2

Predictive Models for Acute and Chronic Health Outcomes

Appendix Table 6.4: Reclassification Statistics for Logistic Regression Models Predicting Incident Hypertension	on
By cancer site, 1997/98-2011/12	

	Integrated			% of Non-			
	Discrimination	Net Reclassification	% of Events	Events			
Models		Improvement (95%	Correctly				
	Improvement (95%	Confidence Interval)	Reclassified	Correctly			
	Confidence Interval)	,		Reclassified			
Bladder							
No. of diagnoses	0.012 (0.000, 0.025)	0.289 (0.058, 0.521)	0.0	28.9			
No. of drugs	0.052 (0.023, 0.081)	0.415 (0.184, 0.645)	6.8	34.7			
No. of ADGs®	0.013 (0.001, 0.025)	0.295 (0.062, 0.527)	6.8	22.6			
Resource Utilization Bands	0.003 (-0.002, 0.008)	0.148 (-0.077, 0.374)	-22.7	37.5			
Chronic Disease Score	0.042 (0.017, 0.066)	0.358 (0.127, 0.589)	4.5	31.2			
Charlson Index	0.005 (-0.002, 0.011)	0.129 (-0.105, 0.362)	4.5	8.3			
Elixhauser	0.049 (0.023, 0.076)	0.455 (0.225, 0.684)	11.4	34.1			
Breast							
No. of diagnoses	0.003 (0.001, 0.005)	0.084 (0.004, 0.163)	-14.2	22.5			
No. of drugs	0.018 (0.013, 0.024)	0.328 (0.249, 0.408)	-1.6	34.4			
No. of ADGs®	0.002 (0.000, 0.003)	0.075 (-0.006, 0.155)	-7.2	14.6			
Resource Utilization Bands	0.001 (0.000, 0.003)	-0.195 (-0.275, -0.115)	0.1	-19.6			
Chronic Disease Score	0.029 (0.022, 0.036)	0.417 (0.338, 0.497)	5.4	36.3			
Charlson Index	0.001 (0.000, 0.003)	0.140 (0.060, 0.219)	-13.6	27.5			
Elixhauser	0.035 (0.027, 0.043)	0.432 (0.355, 0.509)	-20.9	64.1			
Chronic Lymphocytic Leukemia							
No. of diagnoses	0.000 (-0.002, 0.002)	0.062 (-0.215, 0.339)	20.0	-13.8			
No. of drugs	0.031 (0.011, 0.050)	0.393 (0.113, 0.673)	5.5	33.8			
No. of ADGs®	0.000 (-0.002, 0.002)	0.190 (-0.085, 0.466)	23.6	-4.6			
Resource Utilization Bands	0.001 (-0.001, 0.002)	0.081 (-0.199, 0.361)	12.7	-4.6			
Chronic Disease Score	0.028 (0.008, 0.048)	0.424 (0.145, 0.704)	9.1	33.3			
Charlson Index	0.000 (-0.001, 0.001)	0.061 (-0.220, 0.341)	12.7	-6.7			
Elixhauser	0.035 (0.014, 0.056)	0.324 (0.046, 0.603)	-9.1	41.5			
Colorectal		0.104 (0.040, 0.000)	0.0	21.4			
No. of diagnoses	0.006 (0.003, 0.009)	0.124 (0.040, 0.208)	-9.0	21.4			
No. of drugs	0.048 (0.038, 0.057)	0.384 (0.301, 0.468)	3.7	34.7			
No. of ADGs®	0.002 (0.000, 0.004)	0.065 (-0.019, 0.149)	-7.8	14.3			
Resource Utilization Bands	0.001 (0.000, 0.002)	-0.051 (-0.132, 0.030)	-29.2	24.1			
Chronic Disease Score	0.064 (0.053, 0.075) 0.004 (0.002, 0.007)	0.474 (0.391, 0.557)	9.5	37.9			
Charlson Index Elixhauser	0.060 (0.049, 0.072)	0.067 (-0.017, 0.151)	-11.3 -10.1	18.0 52.0			
Lung	0.000 (0.049, 0.072)	0.419 (0.337, 0.501)	-10.1	52.0			
No. of diagnoses	0.009 (0.002, 0.015)	0.141 (-0.002, 0.283)	-7.0	21.1			
No. of drugs	0.051 (0.035, 0.067)	0.426 (0.285, 0.568)	7.0	35.6			
No. of ADGs®	0.006 (0.001, 0.011)	0.181 (0.039, 0.324)	2.6	15.5			
Resource Utilization Bands	0.006 (0.001, 0.011)	0.212 (0.073, 0.352)	25.4	-4.2			
Chronic Disease Score	0.063 (0.045, 0.080)	0.482 (0.342, 0.623)	14.9	33.3			
Charlson Index	0.008 (0.002, 0.014)	0.177 (0.034, 0.320)	-0.9	18.6			
Elixhauser	0.077 (0.056, 0.097)	0.566 (0.427, 0.705)	-0.9	57.5			
Prostate	0.077 (0.030, 0.037)	0.500 (0.727, 0.705)	0.5	57.5			
No. of diagnoses	0.006 (0.003, 0.009)	0.132 (0.049, 0.216)	-10.6	23.8			
No. of drugs	0.026 (0.020, 0.031)	0.364 (0.280, 0.448)	0.9	35.5			
No. of ADGs®	0.004 (0.002, 0.007)	0.139 (0.055, 0.223)	-5.0	18.9			
Resource Utilization Bands	0.000 (0.000, 0.001)	-0.017 (-0.096, 0.061)	-36.8	35.0			
Chronic Disease Score	0.034 (0.028, 0.041)	0.415 (0.332, 0.499)	6.5	35.0			
Charlson Index	0.000 (0.000, 0.001)	0.071 (-0.013, 0.155)	-9.0	16.1			
Elixhauser	0.025 (0.019, 0.031)	0.241 (0.161, 0.321)	-25.2	49.3			
Bold values indicate a statistically si							

Appendix Table 6.5: Reclassification Statistics for Logistic Regression Models Predicting Incident Diabetes

By cancer site, 1997/98-2011/12

.,,	997/98-2011/12		1	
	Integrated	Net Reclassification	% of Events	% of Non-
Models	Discrimination	Improvement (95%	Correctly	Events
Wodels	Improvement (95%	-	-	Correctly
	Confidence Interval)	Confidence Interval)	Reclassified	Reclassified
Bladder				
No. of diagnoses	0.000 (-0.002, 0.002)	0.156 (-0.200, 0.511)	31.0	-15.5
No. of drugs	0.005 (-0.004, 0.015)	0.164 (-0.207, 0.535)	-10.3	26.8
No. of ADGs®	0.000 (-0.001, 0.001)	-0.080 (-0.453, 0.293)	3.4	-11.5
Resource Utilization Bands	0.000 (-0.003, 0.004)	0.114 (-0.248, 0.476)	-24.1	35.5
Chronic Disease Score	0.007 (-0.003, 0.017)	0.288 (-0.085, 0.660)	3.4	25.3
Charlson Index	0.000 (-0.001, 0.001)	-0.040 (-0.411, 0.332)	-10.3	6.4
Elixhauser Index	0.029 (0.001, 0.056)	0.509 (0.147, 0.871)	24.1	26.8
Breast	,,			2010
No. of diagnoses	0.000 (0.000, 0.000)	0.001 (-0.130, 0.131)	-17.2	17.3
No. of drugs	0.003 (0.001, 0.006)	0.227 (0.095, 0.359)	-5.7	28.4
No. of ADGs®	0.000 (0.000, 0.000)	-0.028 (-0.160, 0.104)	8.4	-11.2
Resource Utilization Bands	0.000 (0.000, 0.000)	0.096 (-0.037, 0.228)	-0.4	10.0
Chronic Disease Score	0.005 (0.003, 0.008)	0.267 (0.135, 0.400)	-2.2	28.9
Charlson Index	0.000 (0.000, 0.000)	-0.059 (-0.188, 0.071)	20.7	-26.6
Elixhauser Index	0.018 (0.010, 0.026)	0.400 (0.268, 0.532)	5.7	34.3
Chronic Lymphocytic Leukemia				
No. of diagnoses	0.001 (-0.003, 0.005)	0.014 (-0.349, 0.378)	13.3	-11.9
No. of drugs	0.007 (-0.004, 0.018)	0.258 (-0.108, 0.624)	0.0	25.8
No. of ADGs®	0.001 (-0.004, 0.006)	0.107 (-0.257, 0.470)	13.3	-2.6
Resource Utilization Bands	0.005 (-0.003, 0.012)	0.022 (-0.341, 0.386)	-13.3	15.6
Chronic Disease Score	0.021 (0.004, 0.038)	0.525 (0.166, 0.883)	20.0	32.5
Charlson Index	0.003 (-0.001, 0.007)	0.014 (-0.352, 0.380)	6.7	-5.3
Elixhauser Index	0.048 (0.006, 0.090)	0.302 (-0.041, 0.645)	-33.3	63.6
Colorectal				
No. of diagnoses	0.001 (0.000, 0.001)	0.141 (0.011, 0.271)	-5.9	20.0
No. of drugs	0.009 (0.005, 0.012)	0.335 (0.205, 0.466)	6.7	26.8
No. of ADGs®	0.001 (0.000, 0.002)	0.092 (-0.039, 0.222)	-5.9	15.1
Resource Utilization Bands	0.000 (0.000, 0.001)	0.046 (-0.081, 0.173)	-22.7	27.3
Chronic Disease Score	0.009 (0.005, 0.013)	0.346 (0.216, 0.476)	8.4	26.2
Charlson Index	0.000 (0.000, 0.001)	0.023 (-0.106, 0.152)	-14.3	16.6
Elixhauser Index	0.023 (0.013, 0.032)	0.191 (0.066, 0.316)	-28.6	47.7
Lung		1	1	1
No. of diagnoses	0.000 (-0.001, 0.001)	-0.127 (-0.353, 0.098)	1.3	-14.0
No. of drugs	0.001 (-0.001, 0.002)	0.068 (-0.156, 0.292)	-11.4	18.2
No. of ADGs®	0.002 (-0.001, 0.004)	0.020 (-0.205, 0.246)	3.8	-1.8
Resource Utilization Bands	0.001 (-0.001, 0.002)	0.048 (-0.177, 0.273)	-6.3	11.2
Chronic Disease Score	0.002 (-0.001, 0.004)	0.131 (-0.094, 0.357)	-3.8	16.9
Charlson Index	0.000 (-0.001, 0.002)	-0.038 (-0.260, 0.185)	-16.5	12.7
Elixhauser Index	0.077 (0.039, 0.116)	0.581 (0.358, 0.805)	8.9	49.2
Prostate		0.004/0777-7-7		6 -
No. of diagnoses	0.001 (0.000, 0.003)	0.004 (-0.128, 0.135)	-22.9	23.3
No. of drugs	0.010 (0.005, 0.016)	0.233 (0.098, 0.368)	-7.3	30.7
No. of ADGs®	0.001 (0.000, 0.001)	-0.003 (-0.137, 0.130)	-16.5	16.2
Resource Utilization Bands	0.001 (0.000, 0.003)	0.132 (0.004, 0.261)	-31.2	44.4
Chronic Disease Score	0.011 (0.007, 0.015)	0.391 (0.256, 0.525)	9.2	29.9
Charlson Index	0.001 (0.000, 0.002)	0.091 (-0.044, 0.226)	-9.2	18.3
Elixhauser Index	0.008 (0.004, 0.012)	0.385 (0.251, 0.519)	13.8	24.7

Appendix Table 6.6: Reclassification Statistics for Logistic Regression Models Predicting Incident Congestive Heart Failure

5	
By cancer site, 1997/98-2011/12	

	Integrated			% of Non-			
	Discrimination	Net Reclassification	% of Events	Events			
Models		Improvement (95%	Correctly				
	Improvement (95%	Confidence Interval)	Reclassified	Correctly			
	Confidence Interval)	,		Reclassified			
	Bladder						
No. of diagnoses	0.003 (-0.005, 0.012)	0.078 (-0.288, 0.445)	-17.2	25.1			
No. of drugs	0.026 (0.006, 0.046)	0.427 (0.056, 0.798)	3.4	39.2			
No. of ADGs®	0.001 (-0.003, 0.004)	0.098 (-0.269, 0.465)	17.2	-7.4			
Resource Utilization Bands	0.001 (-0.003, 0.005)	0.167 (-0.193, 0.527)	-24.1	40.8			
Chronic Disease Score	0.040 (0.009, 0.070)	0.598 (0.238, 0.959)	24.1	35.7			
Charlson Index	0.000 (0.000, 0.000)	0.007 (-0.365, 0.379)	-3.4	4.2			
Elixhauser Index	0.023 (0.003, 0.043)	0.386 (0.017, 0.756)	10.3	28.3			
Breast			10	26.0			
No. of diagnoses	0.002 (-0.002, 0.005)	0.212 (0.059, 0.365)	-4.8	26.0			
No. of drugs	0.012 (0.005, 0.018)	0.566 (0.415, 0.716)	16.7	39.9			
No. of ADGs®	0.001 (-0.001, 0.004)	0.225 (0.072, 0.378)	2.4	20.1			
Resource Utilization Bands	0.004 (0.000, 0.008)	0.070 (-0.081, 0.222)	-13.1	20.1			
Chronic Disease Score	0.012 (0.005, 0.019)	0.546 (0.396, 0.697)	16.7	38.0			
Charlson Index	0.004 (0.000, 0.009)	0.386 (0.234, 0.539)	9.5	29.1			
Elixhauser Index	0.040 (0.024, 0.056)	0.609 (0.458, 0.760)	15.5	45.4			
Chronic Lymphocytic Leukemia	0.004 (0.005 0.014)	0.000 0.500	12.2	24.6			
No. of diagnoses	0.004 (-0.006, 0.014)	0.224 (-0.089, 0.536)	-12.2	34.6			
No. of drugs	0.019 (-0.002, 0.040)	0.556 (0.247, 0.866)	17.1	38.6			
No. of ADGs®	0.003 (-0.006, 0.013)	0.141 (-0.172, 0.453)	-12.2	26.3			
Resource Utilization Bands	0.002 (-0.004, 0.009)	0.245 (-0.067, 0.557)	-12.2	36.7			
Chronic Disease Score	0.029 (0.008, 0.051)	0.553 (0.243, 0.863)	17.1	38.2			
Charlson Index	0.003 (-0.006, 0.011)	0.088 (-0.226, 0.403)	-7.3	16.1			
Elixhauser Index Colorectal	0.061 (0.017, 0.105)	0.585 (0.273, 0.897)	-2.4	61.0			
No. of diagnoses	0.007 (0.003, 0.011)	0.134 (0.008, 0.261)	-11.2	24.6			
No. of drugs	0.014 (0.008, 0.020)	0.383 (0.257, 0.510)	4.8	33.5			
No. of ADGs®	0.003 (0.001, 0.005)	0.087 (-0.039, 0.214)	-8.8	17.5			
Resource Utilization Bands	0.006 (0.002, 0.009)	0.251 (0.126, 0.376)	-16.8	41.9			
Chronic Disease Score	0.016 (0.009, 0.022)	0.381 (0.254, 0.507)	5.6	32.5			
Charlson Index	0.003 (0.000, 0.005)	0.095 (-0.031, 0.222)	-11.2	20.7			
Elixhauser Index	0.026 (0.016, 0.036)	0.464 (0.337, 0.590)	0.0	46.4			
Lung	0.020 (0.020, 0.050)	0.101 (0.337, 0.330)	0.0	10.1			
No. of diagnoses	0.004 (-0.001, 0.009)	0.208 (-0.001, 0.418)	-7.7	28.5			
No. of drugs	0.010 (0.002, 0.018)	0.336 (0.126, 0.546)	3.3	30.3			
No. of ADGs®	0.002 (-0.002, 0.007)	0.228 (0.018, 0.438)	3.3	19.5			
Resource Utilization Bands	0.005 (0.000, 0.010)	0.336 (0.128, 0.543)	16.5	17.1			
Chronic Disease Score	0.008 (0.001, 0.015)	0.415 (0.207, 0.623)	14.3	27.2			
Charlson Index	0.003 (-0.002, 0.007)	0.395 (0.187, 0.604)	14.3	25.3			
Elixhauser Index	0.049 (0.025, 0.074)	0.607 (0.400, 0.815)	14.3	46.4			
Prostate	, , , , , ,	,					
No. of diagnoses	0.003 (0.000, 0.007)	0.252 (0.109, 0.394)	0.0	25.2			
No. of drugs	0.008 (0.003, 0.012)	0.424 (0.282, 0.566)	10.3	32.0			
No. of ADGs®	0.003 (0.000, 0.007)	0.261 (0.119, 0.404)	5.2	21.0			
Resource Utilization Bands	0.004 (0.000, 0.008)	0.307 (0.166, 0.447)	-16.5	47.2			
Chronic Disease Score	0.009 (0.004, 0.014)	0.450 (0.308, 0.591)	13.4	31.6			
Charlson Index	0.001 (-0.001, 0.004)	0.174 (0.031, 0.317)	-1.0	18.4			
Elixhauser Index	0.019 (0.009, 0.030)	0.479 (0.337, 0.622)	-2.1	50.0			

Appendix Table 6.7: Reclassification Statistics for Logistic Regression Models Predicting Incident Acute Myocardial Infarction

Models	Integrated Discrimination Improvement (95% Confidence Interval)	Net Reclassification Improvement (95% Confidence Interval)	% of Events Correctly Reclassified	% of Non- Events Correctly Reclassified
All Sites				
No. of diagnoses	0.000 (0.000, 0.001)	0.197 (0.075, 0.318)	-4.2	23.8
No. of drugs	0.001 (0.001, 0.002)	0.271 (0.150, 0.393)	-1.9	29.0
No. of Aggregated Diagnosis Groups™	0.000 (0.000, 0.001)	0.156 (0.035, 0.277)	-0.4	16.0
Resource Utilization Bands	0.000 (0.000, 0.001)	0.284 (0.162, 0.405)	2.7	25.7
Chronic Disease Score	0.001 (0.001, 0.002)	0.272 (0.151, 0.393)	1.1	26.0
Charlson Index	0.001 (0.000, 0.001)	0.267 (0.146, 0.389)	4.9	21.8
Elixhauser Index	0.003 (0.002, 0.004)	0.321 (0.199, 0.442)	1.9	30.2

Bold values indicate a statistically significant difference from the base model at α =0.05

Appendix Table 6.8: Reclassification Statistics for Logistic Regression Models Predicting Incident Osteoporosis-Related Fractures

By cancer site, 1997/98-2011/12

Models	Integrated Discrimination Improvement (95% Confidence Interval)	Net Reclassification Improvement (95% Confidence Interval)	% of Events Correctly Reclassified	% of Non- Events Correctly Reclassified	
Breast					
No. of diagnoses	0.002 (-0.001, 0.005)	0.131 (-0.087, 0.350)	-12.5	25.6	
No. of drugs	0.000 (0.000, 0.001)	0.147 (-0.072, 0.367)	-10.0	24.7	
No. of ADGs®	0.002 (0.000, 0.004)	0.186 (-0.034, 0.406)	-2.5	21.1	
Resource Utilization Bands	0.001 (0.000, 0.002)	0.007 (-0.213, 0.226)	-7.5	8.2	
Chronic Disease Score	0.000 (0.000, 0.000)	0.069 (-0.149, 0.288)	-12.5	19.4	
Charlson Index	0.000 (0.000, 0.001)	0.346 (0.127, 0.564)	12.5	22.1	
Elixhauser Index	0.016 (0.008, 0.025)	0.570 (0.351, 0.790)	7.5	49.5	
Colorectal					
No. of diagnoses	0.000 (-0.001, 0.000)	0.097 (-0.102, 0.295)	-10.2	19.9	
No. of drugs	0.001 (-0.001, 0.002)	0.157 (-0.042, 0.356)	-8.2	23.9	
No. of ADGs®	0.000 (-0.001, 0.001)	0.206 (0.007, 0.406)	4.1	16.6	
Resource Utilization Bands	0.001 (-0.001, 0.002)	0.300 (0.101, 0.499)	0.0	30.0	
Chronic Disease Score	0.000 (-0.001, 0.001)	0.168 (-0.032, 0.367)	-2.0	18.8	
Charlson Index	0.000 (0.000, 0.000)	0.024 (-0.173, 0.222)	12.2	-9.8	
Elixhauser Index	0.003 (0.001, 0.005)	0.383 (0.201, 0.565)	40.8	-2.5	
Lung					
No. of diagnoses	0.000 (0.000, 0.001)	0.063 (-0.116, 0.242)	-11.7	17.9	
No. of drugs	0.000 (0.000, 0.000)	0.014 (-0.165, 0.192)	-15.0	16.4	
No. of ADGs®	0.000 (0.000, 0.000)	0.021 (-0.159, 0.200)	-6.7	8.7	
Resource Utilization Bands	0.000 (0.000, 0.000)	0.006 (-0.174, 0.186)	6.7	-6.0	
Chronic Disease Score	0.000 (-0.001, 0.001)	0.094 (-0.086, 0.274)	-5.0	14.4	
Charlson Index	0.000 (0.000, 0.000)	0.000 (-0.177, 0.176)	20.0	-20.0	
Elixhauser Index	0.008 (0.004, 0.012)	0.489 (0.311, 0.666)	16.7	32.2	
All Sites					
No. of diagnoses	0.001 (0.000, 0.001)	0.157 (0.057, 0.257)	-10.4	26.1	
No. of drugs	0.000 (0.000, 0.001)	0.164 (0.064, 0.264)	-8.3	24.6	
No. of ADGs®	0.001 (0.000, 0.002)	0.248 (0.148, 0.349)	5.2	19.7	
Resource Utilization Bands	0.001 (0.000, 0.001)	0.265 (0.164, 0.365)	0.0	26.5	
Chronic Disease Score	0.000 (0.000, 0.001)	0.186 (0.086, 0.287)	-2.1	20.7	
Charlson Index	0.000 (0.000, 0.000)	0.100 (0.000, 0.201)	-5.7	15.7	
Elixhauser Index	0.004 (0.002, 0.006)	0.350 (0.250, 0.450)	-6.7	41.8	

APPENDIX 7: LOGISTIC REGRESSION MODELS PREDICTING ALL-CAUSE MORTALITY BASED ON CANCER-FREE COMORBIDITY MEASURES

TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENT

Models	c -statistic	Brier score	Δ.ς. (%)
Models	(95% Confidence Interval)	(Standard Deviation)	Δc (%)
Bladder			
Base	0.730 (0.699, 0.761)	0.180 (0.006)	
No. of diagnoses	0.735 (0.705, 0.765)	0.179 (0.006)	0.005 (0.74)
No. of drugs	0.731 (0.701, 0.762)	0.180 (0.006)	0.001 (0.19)
No. of Aggregated Diagnosis Groups™	0.731 (0.701, 0.762)	0.180 (0.006)	0.001 (0.20)
Resource Utilization Bands	0.733 (0.702, 0.763)	0.179 (0.006)	0.003 (0.39)
Chronic Disease Score	0.730 (0.699, 0.760)	0.180 (0.006)	0.000 (-0.01)
Charlson Index	0.742 (0.712, 0.772)	0.176 (0.006)	0.012 (1.71)
Elixhauser Index	0.774 (0.745, 0.802)	0.167 (0.006)	0.044 (6.05)
Breast	<u>.</u>		
Base	0.898 (0.883, 0.913)	0.037 (0.002)	
No. of diagnoses	0.900 (0.885, 0.915)	0.037 (0.002)	0.002 (0.18)
No. of drugs	0.901 (0.887, 0.916)	0.037 (0.002)	0.003 (0.34)
No. of Aggregated Diagnosis Groups™	0.899 (0.884, 0.914)	0.037 (0.002)	0.001 (0.12)
Resource Utilization Bands	0.898 (0.884, 0.913)	0.037 (0.002)	0.000 (0.02)
Chronic Disease Score	0.902 (0.887, 0.916)	0.037 (0.002)	0.003 (0.37)
Charlson Index	0.900 (0.885, 0.915)	0.037 (0.002)	0.002 (0.21)
Elixhauser Index	0.907 (0.892, 0.921)	0.037 (0.001)	0.008 (0.93)
Chronic Lymphocytic Leukemia			
Base	0.786 (0.730, 0.841)	0.065 (0.006)	
No. of diagnoses	0.804 (0.749, 0.860)	0.064 (0.006)	0.019 (2.38)
No. of drugs	0.796 (0.742, 0.849)	0.065 (0.006)	0.010 (1.25)
No. of Aggregated Diagnosis Groups™	0.801 (0.746, 0.856)	0.065 (0.006)	0.015 (1.93)
Resource Utilization Bands	0.803 (0.745, 0.861)	0.062 (0.006)	0.018 (2.24)
Chronic Disease Score	0.791 (0.735, 0.847)	0.065 (0.006)	0.005 (0.66)
Charlson Index	0.794 (0.739, 0.849)	0.065 (0.006)	0.008 (1.03)
Elixhauser Index	0.838 (0.786, 0.889)	0.058 (0.006)	0.052 (6.60)
Colorectal			
Base	0.812 (0.800, 0.824)	0.125 (0.002)	
No. of diagnoses	0.815 (0.803, 0.827)	0.124 (0.002)	0.003 (0.36)
No. of drugs	0.814 (0.802, 0.825)	0.125 (0.002)	0.001 (0.14)
No. of Aggregated Diagnosis Groups™	0.815 (0.803, 0.827)	0.124 (0.002)	0.003 (0.35)
Resource Utilization Bands	0.817 (0.805, 0.828)	0.124 (0.002)	0.004 (0.51)
Chronic Disease Score	0.813 (0.801, 0.825)	0.125 (0.002)	0.001 (0.12)
Charlson Index	0.816 (0.804, 0.828)	0.124 (0.002)	0.004 (0.46)
Elixhauser Index	0.820 (0.808, 0.832)	0.123 (0.002)	0.008 (0.97)
Lung			
Base	0.784 (0.774, 0.794)	0.174 (0.002)	
No. of diagnoses	0.784 (0.774, 0.794)	0.174 (0.002)	0.000 (0.01)
No. of drugs	0.784 (0.774, 0.794)	0.174 (0.002)	0.000 (-0.01)
No. of Aggregated Diagnosis Groups™	0.784 (0.774, 0.794)	0.174 (0.002)	0.000 (0.00)
Resource Utilization Bands	0.785 (0.774, 0.795)	0.174 (0.002)	0.001 (0.07)
Chronic Disease Score	0.784 (0.774, 0.794)	0.174 (0.002)	0.000 (-0.04)
Charlson Index	0.784 (0.774, 0.794)	0.174 (0.002)	0.000 (-0.01)
Elixhauser Index	0.789 (0.779, 0.799)	0.173 (0.002)	0.005 (0.59)
Prostate			
Base	0.795 (0.773, 0.816)	0.052 (0.002)	
No. of diagnoses	0.808 (0.788, 0.829)	0.051 (0.002)	0.014 (1.73)
No. of drugs	0.804 (0.783, 0.825)	0.051 (0.002)	0.009 (1.18)
No. of Aggregated Diagnosis Groups™	0.806 (0.785, 0.827)	0.052 (0.002)	0.011 (1.42)
Resource Utilization Bands	0.799 (0.778, 0.820)	0.052 (0.002)	0.004 (0.54)
Chronic Disease Score	0.806 (0.785, 0.826)	0.051 (0.002)	0.011 (1.36)
Charlson Index	0.809 (0.788, 0.830)	0.051 (0.002)	0.014 (1.79)
Elixhauser Index	0.816 (0.795, 0.836)	0.050 (0.002)	0.021 (2.64)

By cancer site, 1997/98-2011/12

Bold values indicate a statistically significant difference from the base model at α =0.05

TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENTURER REBEL PIONEER CREATOR EXPLORER CREATOR EXPLORER DEFENDER TRAILBLAZER CHALLENGER VISIONARY INNOVATOR ADVENT

• •	Integrated			% of Non-
	Discrimination	Net Reclassification	% of Events	Events
Models	Improvement (95%	Improvement (95%	Correctly	Correctly
	Confidence Interval)	Confidence Interval)	Reclassified	Reclassified
Bladder	Confidence Intervan		1	Reclassifieu
No. of diagnoses	0.005 (0.000, 0.010)	0.101 (-0.018, 0.220)	-14.8	24.9
No. of drugs	0.002 (-0.001, 0.006)	0.121 (0.002, 0.241)	-11.1	23.2
No. of Aggregated Diagnosis Groups™	0.002 (-0.001, 0.004)	0.105 (-0.015, 0.225)	-6.9	17.4
Resource Utilization Bands	0.003 (-0.001, 0.007)	0.080 (-0.037, 0.197)	-22.8	30.8
Chronic Disease Score	0.000 (0.000, 0.000)	0.063 (-0.058, 0.183)	-9.0	15.3
Charlson Index	0.019 (0.010, 0.028)	0.208 (0.089, 0.328)	-6.9	27.7
Elixhauser Index	0.062 (0.045, 0.079)	0.458 (0.345, 0.571)	-14.3	60.1
Breast			•	1
No. of diagnoses	0.002 (-0.001, 0.005)	0.098 (0.005, 0.191)	-13.2	23.0
No. of drugs	0.004 (-0.001, 0.008)	0.212 (0.119, 0.306)	-8.4	29.7
No. of Aggregated Diagnosis Groups™	0.001 (-0.002, 0.003)	0.094 (0.000, 0.187)	-6.7	16.1
Resource Utilization Bands	0.000 (-0.001, 0.001)	-0.182 (-0.275, -0.088)	1.9	-20.1
Chronic Disease Score	0.003 (-0.001, 0.007)	0.245 (0.151, 0.338)	-4.5	29.0
Charlson Index	0.005 (0.000, 0.009)	0.199 (0.108, 0.291)	-18.8	38.7
Elixhauser Index	0.015 (0.008, 0.023)	0.177 (0.087, 0.267)	-27.0	44.7
Chronic Lymphocytic Leukemia				
No. of diagnoses	0.017 (0.001, 0.032)	0.327 (0.077, 0.578)	0.0	32.7
No. of drugs	0.007 (-0.004, 0.018)	0.307 (0.057, 0.558)	-3.0	33.8
No. of Aggregated Diagnosis Groups™	0.014 (0.000, 0.027)	0.317 (0.067, 0.567)	9.1	22.6
Resource Utilization Bands	0.036 (0.013, 0.058)	0.341 (0.091, 0.592)	6.1	28.1
Chronic Disease Score	0.007 (-0.003, 0.017)	0.212 (-0.038, 0.463)	-6.1	27.3
Charlson Index	0.005 (-0.006, 0.016)	0.401 (0.151, 0.651)	6.1	34.0
Elixhauser Index	0.099 (0.053, 0.144)	0.723 (0.480, 0.967)	21.2	51.1
Colorectal			•	
No. of diagnoses	0.002 (0.001, 0.004)	0.126 (0.074, 0.178)	-11.2	23.8
No. of drugs	0.001 (0.000, 0.002)	0.126 (0.074, 0.178)	-8.5	21.1
No. of Aggregated Diagnosis Groups™	0.003 (0.001, 0.004)	0.164 (0.112, 0.217)	-1.5	18.0
Resource Utilization Bands	0.004 (0.002, 0.005)	0.079 (0.028, 0.130)	-18.7	26.6
Chronic Disease Score	0.001 (0.000, 0.002)	0.108 (0.056, 0.160)	-6.8	17.6
Charlson Index	0.002 (0.001, 0.004)	0.172 (0.120, 0.223)	-12.4	29.6
Elixhauser Index	0.010 (0.008, 0.013)	0.136 (0.085, 0.188)	-14.2	27.8
Lung	· · · ·		•	•
No. of diagnoses	0.000 (0.000, 0.001)	0.034 (-0.009, 0.077)	-15.1	18.5
No. of drugs	0.000 (0.000, 0.000)	-0.001 (-0.044, 0.042)	-13.4	13.4
No. of Aggregated Diagnosis Groups™	0.000 (0.000, 0.000)	-0.022 (-0.065, 0.021)	7.9	-10.1
Resource Utilization Bands	0.000 (0.000, 0.001)	0.030 (-0.012, 0.073)	23.6	-20.5
Chronic Disease Score	0.000 (0.000, 0.001)	0.060 (0.017, 0.103)	-6.2	12.2
Charlson Index	0.000 (0.000, 0.000)	-0.066 (-0.109, -0.023)	-15.6	9.0
Elixhauser Index	0.004 (0.003, 0.005)	0.093 (0.050, 0.137)	2.8	6.5
Prostate				
No. of diagnoses	0.015 (0.008, 0.021)	0.303 (0.209, 0.398)	-2.4	32.7
No. of drugs	0.010 (0.006, 0.015)	0.321 (0.227, 0.416)	2.0	30.1
No. of Aggregated Diagnosis Groups™	0.010 (0.005, 0.015)	0.284 (0.189, 0.379)	4.2	24.2
Resource Utilization Bands	0.005 (0.002, 0.009)	0.066 (-0.027, 0.160)	-16.5	23.1
Chronic Disease Score	0.011 (0.006, 0.016)	0.304 (0.209, 0.398)	2.9	27.5
Charlson Index	0.019 (0.012, 0.027)	0.352 (0.258, 0.447)	-5.1	40.3
Elixhauser Index	0.035 (0.024, 0.045)	0.371 (0.277, 0.464)	-13.0	50.0

Drugs) By cancer site, 1997/98-2011/12

Bold values indicate a statistically significant difference from the base model at α =0.05

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