

Demographics for Interior BC Cancer Patient Population

Capstone Project Report



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Executive Summary

Previous studies suggest the existence of regional variations in cancer outcomes across Canada and British Columbia (B.C.). In collaboration with BC Cancer - Kelowna, which is a program of B.C. Provincial Health Services Authority, we proposed this project that aimed to examine if such geographic variations across cancer outcomes, specifically cancer incidence and cancer mortality, reside in health service delivery areas (HSDAs) and local health areas (LHAs) of Interior Health (IH), B.C. As a step toward understanding the differences, the cancer types and age groups are studied. Throughout the project, we utilized statistical approaches, including the Chi-square test and ANOVA test, to obtain a structured analysis of regional differences across cancer types and HSDAs paired with tables and visualizations by cancer incidence and mortality across the past five years (2012 to 2016).

There are some key findings from this work which include:

- HSDAs
 - No statistical evidence between regions was found regarding the distribution of cancer types amongst HSDAs.
 - Kootenay Boundary had the highest incidence rate and mortality rate each of four types of cancer amongst all HSDAs.
 - There was no difference in breast cancer incidence across all the HSDAs. However, there was a significantly higher breast cancer mortality rate in the Kootenay boundary, which was probably due to the lowest bi-annual screening participation rate, indicating people may have less chance to be diagnosed at an early stage.
- LHAs
 - Incidence and mortality distribution of cancer types across all LHAs were overall similar to those of the HSDAs as a whole.
 - Across the ten cancer types, there were some dissimilar performances of incidence in different LHAs under each HSDA. Specifically, under East Kootenay, cancer genito-urology had the highest incidence rate in Creston while the lowest one in Fernie.

As to improve the accuracy of the result, more numerical data is supposed to be collected at the LHA level. For future directions in this line of work, we hope to study the factors of health characteristics and amenity proximities that may affect the rate of people having cancer in HSDAs and conduct a statistical significance test (Student's t-test) to find the correlated health characteristics that hold for the population.

Introduction

Cancer incidence and mortality rates are not uniform across Canada. To a large extent, variations between these indicators reflect geographic differences in the extent of cancer control practices, such as screening and treatment (Gaudette et al., 1998). Exploring disparities in cancer outcomes between regions are vital for evaluating current cancer-related health policies and improving the distribution of medical power in the future.

In response, based on an electronic medical record system, BC Cancer proposed a project to examine cancer care indicators from a demographic perspective. This report uses five years of data (2012 to 2016) to analyze differences in cancer incidence and mortality across Health Service Delivery Areas (HSDAs) and Local Health Areas (LHAs) in the Interior Health (IH). Cancer incidence and mortality are further classified by cancer types and age groups to answer the following questions:

- Do there exist differences in incidence and mortality regarding the distribution of cancer types amongst HSDAs and LHAs?
- Do there exist differences in incidence and mortality by cancer type amongst HSDAs and LHAs?
- How does incidence and mortality change by ten cancer types across each HSDA and LHA?
- How does incidence and mortality by ten cancer types change by age groups across each HSDA and LHA?

In this report, we firstly introduce the background of the project, describe all datasets involved, explain steps used to prepare data, and account for methodologies applied for implementation. Then, we would illustrate a detailed analysis of outcomes, and conclude with the main outcomes, barriers, limitations, and future directions.

Background

Cancer is recognized as a major health issue in Canada, as one in two Canadians is projected to be diagnosed with cancer in their lifetime, and about one in four Canadians will die of cancer (“Canadian Cancer Statistics,” 2017). The odds of Canadians getting cancer or dying, unexpectedly depend on whether they live in the West or East, in North or South, and remote cities or urban areas (Blackwell, 2017). There are geographical differences in cancer incidence and mortality rates at the national levels because of territorial variations in risk behaviours, like

smoking prevalence and dietary habits, and the extent of cancer control programs, such as screening and degrees of access to cancer treatments, also significantly affects patients' cancer outcomes and survival (Gaudette et al., 1998). The overall incidence rates are on average higher in eastern and northern Canada than in western and southern Canada, especially for high incidence rates in lung cancer in Quebec and Nunavut due to the relatively high smoking rates and outdated screening programs in that province or territory (Blackwell, 2017).

At the provincial level, we focus on British Columbia (B.C.), which has led the country with its lower cancer incidence and mortality rates for many years (“BC continues to have lowest cancer incidence and mortality rates in Canada,” 2013). For B.C., the provincial average of the incidence rate of 412 per 100,000 males and 324 per 100,000 females, and death rate of 171 per 100,000 males and 130 per 100,000 females (“Statistics confirm BC has lowest cancer incidence and death rates in Canada again in 2011 and lowest incidence of colorectal cancer,” 2011). British Columbia 2011 Regional Cancer Report (n.d.) Compared incidence and mortality rate in Health Authorities with the B.C. provincial average. Vancouver Coastal Region had lower incidence rates and death rates than the provincial average. Incidence rates in Vancouver Island Health for some cancers were more than the provincial average. More incidence cases of lung cancer were found in Northern Health, while other cancers were similar to those of the province. Incidence and mortality rates in the Interior Health and Fraser Health region were similar to the provincial average but differed to the other three HAs in B.C. (“British Columbia 2011 Regional Cancer Report,” n.d., sec. 8.2 pp.51-53).

In the Interior Health region, it has been observed that disparities exist in access to cancer treatments between HSDA's. Although there exist Community Oncology Network clinics areas across Interior BC that can provide oncology services, patients still need to travel to BC Cancer Kelowna Centre for more complex and specialty oncology treatments. For example, it takes patients from Penticton only on average one-hour driving to Kelowna. However, patients from Williams Lake have to drive on average five-hours to receive treatment in Kelowna. Disparate availability of access to cancer treatments could result in different cancer outcomes for patients living further from cancer centers and cancer services. It is of interest to investigate further if there exist geographical differences in cancer outcomes among HSDAs and LHAs across the IH region.

Datasets

All data involved in the project are retrieved from the Cancer Agency Information System (CAIS) at BC Cancer from 2012 to 2016. In this section, details about the primary dataset and steps for data preparation will be disclosed.

Original Datasets

The original dataset referred to in the project is de-identified, which includes nine parameters: geographical type, geographical ID, Health Area, HDSA, LHA, year, cancer type, sex, and age groups. Additionally, two parameters, incidence counts and mortality counts are recorded as the combination of both numerical, which are from 5 to 43, and categorical variables of ‘less than 5’. Incidence counts are the number of newly diagnosed cancers, while mortality is the number of deaths by cancer type. There are 24 types of cancer for 16 age groups.

According to administrative boundaries set by the Ministry of Health published on the official website of the Government of B.C., IH, one of the Health Authorities in B.C., consists of four HSDAs: East Kootenay, Kootenay Boundary, Okanagan, and Thompson Cariboo Shuswap. Besides, each HSDA is made up of numerous LHAs.

Health Area	Health Service Delivery Area	Local Health Area
Interior health	East Kootenay	Cranbrook Creston Ferne Golden Kimberley Windermere
	Kootenay Boundary	Arrow Lakes Castlegar Grand Forks Kettle Valley Kootenay Lake Nelson Trail
	Okanagan	Armstrong-Spallumcheen Central Okanagan Enderby Keremeos Penticton Princeton Southern Okanagan Summerland Vernon
	Thompson Cariboo Shuswap	100 Mile House Cariboo-Chilcotin Kamloops Lillooet Merritt North Thompson Revelstoke Salmon Arm South Cariboo

To eliminate the bias caused by the size of the population, we retrieved one more dataset about the population of all LHAs in British Columbia from 2012 to 2016 from the Demography and Population Statistics, BC Stats. This dataset will be applied to calculate the rate of cancer incidence and mortality in each HSDA or LHA. The detailed step will be explained in the data preparation.

Data Preparation

For the categorical variables ‘less than 5’ in our original dataset, we applied the uniform distribution to randomly insert the numerical variables from 1 to 4 to replace the categorical variable ‘less than 5’ to avoid bias. Besides, we merged both cancer types and age groups into a new method of grouping as listed below. To be specific, 24 cancer types were merged into ten cancer types as advised by a BC Cancer medical representative, as well as 16 age groups were combined into five age groups as suggested by Canadian Cancer Statistics in 2019 (Canadian Cancer Statistics Advisory Committee, 2019).

Cancer Type	<ol style="list-style-type: none"> 1. Brain 2. Breast 3. Gastrointestinal (Esophagus; Stomach; Colorectal; Liver; Pancreas) 4. Thoracic (Lung) 5. Gynaecology (Ovary; Cervix; Body of Uterus) 6. Genito-Urology (Kidneys; Bladder; Prostate; Testis) 7. Hematology/Lymphoma (Leukemia; Hodgkin Lymphoma; Non-hodgkin Lymphoma; Multiple Myeloma) 8. Head & Neck (Oral; Larynx; Thyroid) 9. Skin (Melanoma) 10. All other cancers
Age Group	<ol style="list-style-type: none"> 1. 15-29 (15-19; 20-24; 25-29) 2. 30-49 (30-34; 35-39; 40-44; 44-49) 3. 50-69 (50-54; 55-59; 60-64; 65-69) 4. 70-84 (70-74; 75-79; 80-84) 5. 85+ (85-89; 90+)

Furthermore, as the size of the population in each HSDA and LHA does affect on the total count of both incidence and mortality cases in those regions due to population size, we calculated the rate of cancer incidence and mortality in each HSDA or LHA by the formula using BC Stats for population census data:

$$rate (\%) = \frac{count}{population} * 100$$

Methodology

R Studio (Version 1.2.1572) was used for all statistical tests, Microsoft Excel (Version 16.37) was used to construct descriptive statistics tables, and Tableau (Version 2020.1) was used to create appropriate interactive data visualizations.

Chi-Square Test

The Chi-square test of independence is used to determine whether there is a significant relationship between two categorical variables or not (Diez et al., 2019, p. 240). In our analysis, the chi-square test is used to check the independence between HSDAs and cancer types, to determine whether the distribution of cancer types amongst HSDAs varies, which refers to our first objective.

Null Hypothesis (H_0): HSDAs and cancer types are independent. In other words, there is no difference in the ratio of cancer types in all of the HSDAs.

Alternative Hypothesis (H_1): HSDAs and cancer types depend on one another. In other words, at least one of the HSDAs has a ratio of cancer types, which is different from the ratio of the other HSDA.

If the chi-square test statistic is small (i.e. $p\text{-value} \leq 0.05$), there is evidence to reject the null hypothesis, which means there is a relationship between HSDAs and cancer types. Otherwise, if the chi-square test statistic is a $p\text{-value} > 0.05$, there is no evidence to reject the null hypothesis, which means HSDAs and cancer types are independent of each other.

ANOVA Test

ANOVA test is an effective method to check if several samples have equal means, and is broadly used to study if there exists a significant difference in means between different levels of a categorical variable (Diez et al., 2019, p.285). In our case, the ANOVA test is used to test the equality of the mean of:

- *Incidence/Mortality Rates by HSDAs or LHAs under each Cancer Type*
- *Incidence/Mortality Rates by Cancer Types in each HSDA or LHA*
- *Incidence/Mortality Rates by Cancer Types under each Age Group and each HSDA or LHA*

The first test above related to our objective that aim to find differences in cancer incidence and mortality rates for each cancer type among HSDAs or LHAs (under each HSDA), the rest of tests above aims to find differences in cancer incidence and mortality rates for each HSDA or LHA among ten cancer types with or without age effect. All tests highlight the highest and lowest rates if values are unequal.

Null Hypothesis (H_0): all the mean are equal

Alternative Hypothesis (H_1): at least one mean is not equal

If the $p\text{-value} \leq 0.05$, there is evidence to reject the null hypothesis, which means at least one mean is not equal. Otherwise, if the $p\text{-value} > 0.05$, there is no evidence to reject the null hypothesis, which proves the equality of the mean.

Analysis

Health Service Delivery Area

General Pattern in HSDAs

For a better understanding of the population demographics by HSDAs, please refer to the table in Appendix A1.

Chi-square Test

Chi-square tests are conducted on Table 1.1.1 and Table 1.1.2 below:

Table 1.1.1 Cancer Incidence Counts of 10 cancer types across Interior B.C.'s HSDAs, 2012-2016				
Cancer Type\ HSDA	East Kootenay	Kootenay Boundary	Okanagan	Thompson Cariboo Shuswap
All Other Cancers	69	79	236	159
Brain	10	17	53	40
Breast	78	87	371	212
Gastrointestinal	154	194	634	397
Genito-Urology	133	193	615	407
Gynaecology	38	43	187	106
Head & Neck	43	46	165	108
Hematology/Lymphoma	85	103	351	234
Skin	47	47	151	73
Thoracic	98	95	395	251

Table 1.1.2 Cancer Mortality Counts of 10 cancer types across Interior B.C.'s HSDAs, 2012-2016				
Cancer Type \ HSDA	East Kootenay	Kootenay Boundary	Okanagan	Thompson Cariboo Shuswap
All Other Cancers	44	51	132	100
Brain	7	12	53	40
Breast	20	27	85	64
Gastrointestinal	85	124	342	230
Genito-Urology	49	67	193	127
Gynaecology	13	17	73	44
Head & Neck	7	11	46	32
Hematology/Lymphoma	34	43	138	100
Skin	8	9	28	9
Thoracic	74	77	284	181

Table 1.1.3 Chi-square test result			
Cancer Incidence Statistic	Cancer Incidence p-value	Cancer Mortality Statistic	Cancer Mortality p-value
27.54	0.44	23.06	0.68

Using the assumption of a $p\text{-value} > 0.05$, we found no statistical evidence to reject the null hypothesis, HSDAs and cancer types are independent. In other words, there is no difference in the ratio of incidence and mortality counts of ten cancer types in four health regions (HSDAs).

Visualization

Figure 1.1.4 below supports the chi-square test results of the uniform cancer type distribution amongst HSDAs. It also indicates that across all HSDA's, the highest incidence was observed for gastrointestinal(GI) and genito-urology(GU) cancer types. The highest mortality was reported for GI and thoracic cancers.

(For a detailed table, please refer to Appendix B.1.1 and B.1.2)

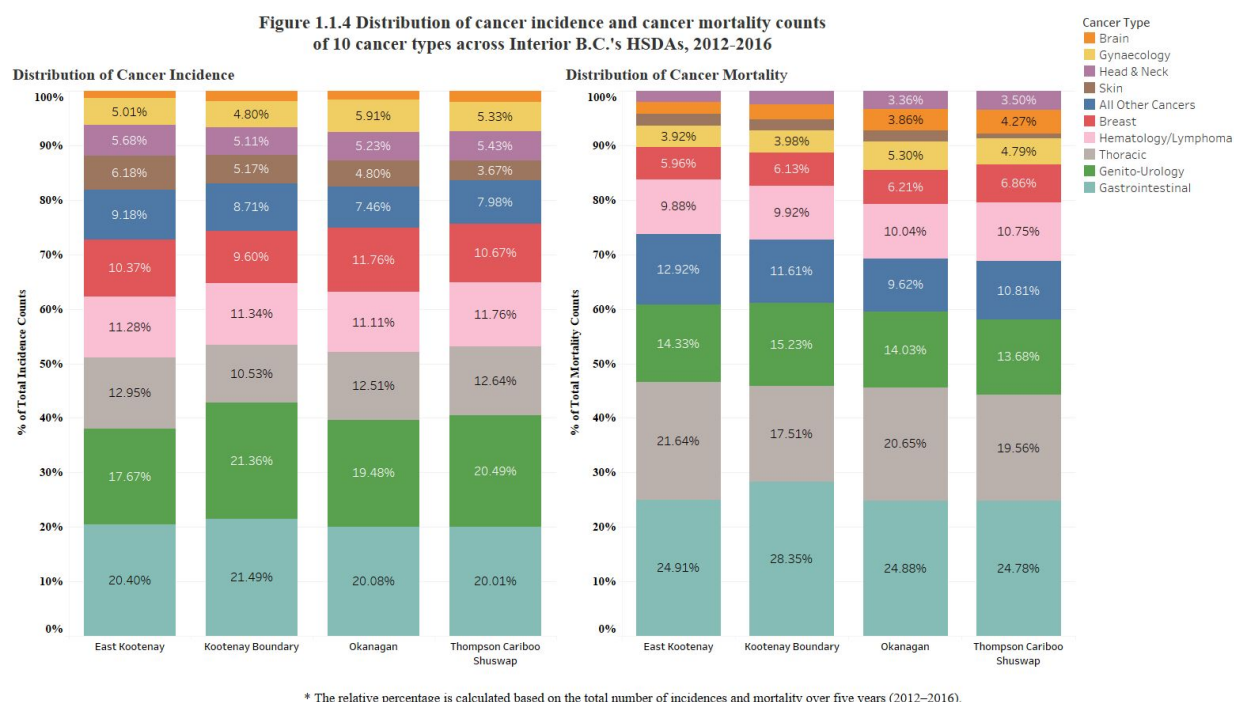


Figure 1.1.5 further demonstrates the distribution of incidence and mortality counts of ten cancer types under each age group in 4 HSDAs.

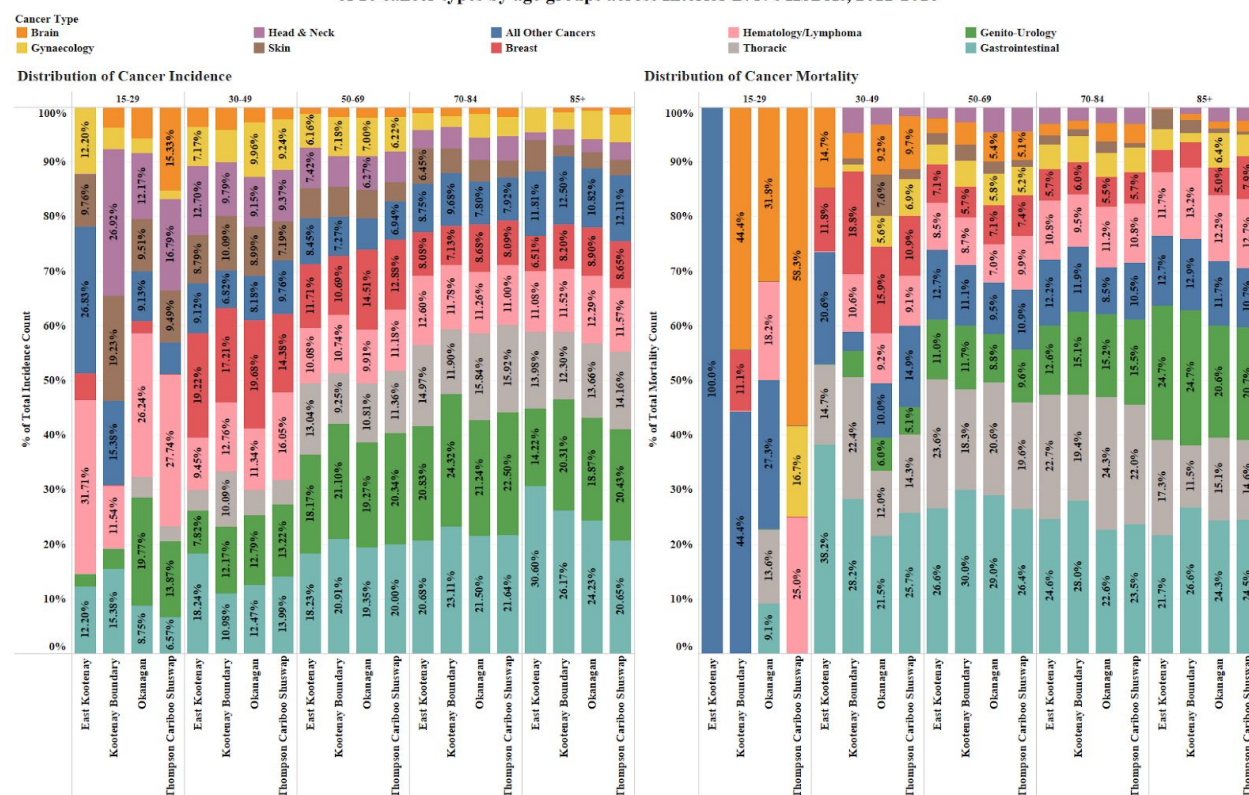
There exists greater variation across cancer types in young age ranges than older people as the data size for the younger age group is smallest, there will be the largest statistical uncertainty in its incidence and mortality rates. A clear pattern of cancer types is seen amongst older age groups across all HSDAs, especially with larger sample sizes, specifically seen in age groups 50-85 for cancer incidence and mortality.

- Among people aged 50 to 85+, in all HSDAs, the most commonly diagnosed cancers were GU and GI cancer.

- Among people aged 50 to 84, in all HSDAs, the cause of the most common cancers of death was GI and thoracic cancer. Among people aged 85+, in all HSDAs, the cause of the most common cancers of death was GI and GU cancer

(For a detailed % table, please refer to Appendix B.1.3 and B.1.4.).

Figure 1.1.5 Distribution of cancer incidence and cancer mortality counts of 10 cancer types by age groups across Interior B.C.'s HSDAs, 2012-2016



* The relative percentage is calculated based on the total number of incidences and mortality over five years (2012–2016) in each HSDA.

Differences among HSDAs

ANOVA Test Outcomes

The result of the ANOVA test, which is used to test the equality of mean, is presented here with highlight tables. All averages are compared by rows. When all the means are tested and are equal to each other (meaning no differences), dashes are inserted in the rows. If the mean of a particular cancer type appears to have a significant difference among all HSDAs, the row will specify the HSDA with the highest or lowest mean and will be tagged as 'highest' in red and 'lowest' in blue. Likewise, we use the same highlight to represent the highest or lowest mean of a specified cancer type among all regions. Additionally, two more tables are constructed under each age group to highlight the highest and lowest of the means for all cancer types in each HSDA.

- *Incidence/Mortality Rates of all HSDAs under each Cancer Type*

Table 1.2.1 Test the equality of means for incidence rates in all HSDAs under each cancer type across Interior Region of B.C. 2012-2016				
	East Kootenay	Kootenay Boundary	Okanagan	Thompson Cariboo Shuswap
All Cancer Types		Highest	Lowest	
Brain	-	-	-	-
Breast	-	-	-	-
Gastrointestinal		Highest	Lowest	
Genito-Urology	Lowest	Highest		
Gynaecology	-	-	-	-
Head & Neck	-	-	-	-
Hematology/Lymphoma	-	-	-	-
Skin		Highest		Lowest
Thoracic	-	-	-	-

Table 1.2.2 Test the equality of means for mortality rates in all HSDAs under each cancer type across Interior Region of B.C. 2012-2016				
	East Kootenay	Kootenay Boundary	Okanagan	Thompson Cariboo Shuswap
All Cancer Types		Highest	Lowest	
Brain	-	-	-	-
Breast		Highest	Lowest	
Gastrointestinal		Highest	Lowest	
Genito-Urology		Highest	Lowest	
Gynaecology	-	-	-	-
Head & Neck	-	-	-	-
Hematology/Lymphoma	-	-	-	-
Skin	-	-	-	-
Thoracic	-	-	-	-

Tables 1.2.1 and 1.2.2 examined the mean of incidence or mortality rates from 2012 to 2016, amongst all 4 HSDAs by each cancer type. According to these tables, among all HSDAs, Kootenay Boundary had the highest incidence rate for all other cancers, GI, GU, and skin cancers, and the highest mortality rate in all other cancers, breast, GI, and GU cancers.

Notably, there were no differences in breast cancer incidence across all the HSDAs. However, there was a significant difference in breast cancer mortality in the Kootenay boundary HSDA relative to other HSDAs, which shows an apparent disparity. According to the BC Cancer Breast Screening report in 2018, Kootenay Boundary had the lowest biennial screening participation rate compared to the other three HSDAs in the IH and the province, which indicates that people who lived in that area may have less chance to be diagnosed at an early stage (BC Cancer, 2019). As a result of lower screening rates, breast cancer is diagnosed later and the start of treatment is delayed, resulting in a decrease in the chance of survival.

- *Incidence/Mortality Rates of all Cancer Types in each HSDA*

Table 1.2.3 Test the equality of means for incidence rates in all cancer types under each HSDA across Interior Region of B.C. 2012-2016										
	All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
East Kootenay		Lowest		Highest						
Kootenay Boundary		Lowest			Highest					
Okanagan		Lowest		Highest						
Thompson Cariboo Shuswap		Lowest			Highest					

Table 1.2.4 Test the equality of means for mortality rates in all cancer types under each HSDA across Interior Region of B.C. 2012-2016										
	All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
East Kootenay				Highest					Lowest	
Kootenay Boundary				Highest			Lowest			
Okanagan				Highest					Lowest	
Thompson Cariboo Shuswap				Highest					Lowest	

Tables 1.2.3 and 1.2.4 examined the means of incidence or mortality rates from 2012 to 2016, amongst all ten cancer types in each HSDA. Unlike tables 1.2.1 and 1.2.2, which compared means amongst all HSDAs by each cancer type instead. Results are the same as those of the Interior Region as a whole, with the pattern of GI and GU being the highest for incidence and GI being the highest for mortality. No apparent disparities were found in any HSDA regards to cancer types distribution.

- *Incidence/Mortality Rates of all Cancer Types under each Age Group and each HSDA*

Table 1.2.5 Test the equality of means for incidence rates in all cancer types under each age group & each HSDA across Interior Region of B.C. 2012-2016											
		All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
15-29	East Kootenay	-	-	-	-	-	-	-	-	-	-
	Kootenay Boundary	-	-	-	-	-	-	-	-	-	-
	Okanagan			Lowest					Highest		
	Thompson Cariboo Shuswap			Lowest					Highest		
30-49	East Kootenay		Lowest	Highest							
	Kootenay Boundary	-	-	-	-	-	-	-	-	-	-
	Okanagan		Lowest	Highest							
	Thompson Cariboo Shuswap		Lowest						Highest		
50-69	East Kootenay		Lowest			Highest	Highest				
	Kootenay Boundary		Lowest								
	Okanagan		Lowest		Highest						
	Thompson Cariboo Shuswap		Lowest			Highest					
70-84	East Kootenay		Lowest				Highest				
	Kootenay Boundary		Lowest				Highest				
	Okanagan		Lowest		Highest						
	Thompson Cariboo Shuswap		Lowest			Highest					
85+	East Kootenay		Lowest		Highest						
	Kootenay Boundary		Lowest		Highest						
	Okanagan		Lowest		Highest						
	Thompson Cariboo Shuswap		Lowest		Highest						

Table 1.2.6 Test the equality of means for mortality rates in all cancer types under each age group & each HSDA across Interior Region of B.C. 2012-2016											
		All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
15-29	East Kootenay	-	-	-	-	-	-	-	-	-	-
	Kootenay Boundary	-	-	-	-	-	-	-	-	-	-
	Okanagan	-	-	-	-	-	-	-	-	-	-
	Thompson Cariboo Shuswap	-	-	-	-	-	-	-	-	-	-
30-49	East Kootenay	-	-	-			-		-		-
	Kootenay Boundary				Highest					Lowest	
	Okanagan				Highest			Lowest			
	Thompson Cariboo Shuswap				Highest			Lowest		Lowest	
50-69	East Kootenay				Highest			Lowest			
	Kootenay Boundary				Highest			Lowest			
	Okanagan				Highest					Lowest	
	Thompson Cariboo Shuswap				Highest					Lowest	
70-84	East Kootenay				Highest					Lowest	
	Kootenay Boundary				Highest					Lowest	
	Okanagan									Lowest	Highest
	Thompson Cariboo Shuswap				Highest					Lowest	
85+	East Kootenay		Lowest			Highest					
	Kootenay Boundary		Lowest		Highest						
	Okanagan				Highest					Lowest	
	Thomson Cariboo Shuswan				Highest					Lowest	

Tables 1.2.5 and 1.2.6 each have five sections. Each section compares the averages of incidence or mortality rates of all ten cancer types between HSDAs in the corresponding age group. Besides the general pattern of brain cancers being the rarest and GI and GU cancers being the most prevalent in cancer incidence, disparities are observed in young age groups. Amongst the population aged 15 to 29, the incidence of hematology/lymphoma cancer was most readily seen

in Okanagan and Thompson Cariboo Shuswap HSDA's. Amongst residents aged 30 to 49, Thompson Cariboo Shuswap had higher diagnoses of hematology/lymphoma cancers relative to other HSDAs, and in the East Kootenay and Okanagan, greater incidence of breast cancers relative to other HSDAs.

For the 15-29 age group for cancer mortality rate and cancer types by HSDAs, there is data limitation of a single-digit mortality count reported, which leads to high statistical uncertainty. Therefore, non-concrete conclusions can be made on that data.

Across patients aged inclusive from age 50 onwards to 85+, GI cancer was identified to be the most common cause of cancer deaths relative to other cancer types in all HSDAs. However, thoracic and GU cancers mostly appeared in the 70-84 age group in Okanagan and the 85+ age group in East Kootenay respectively.

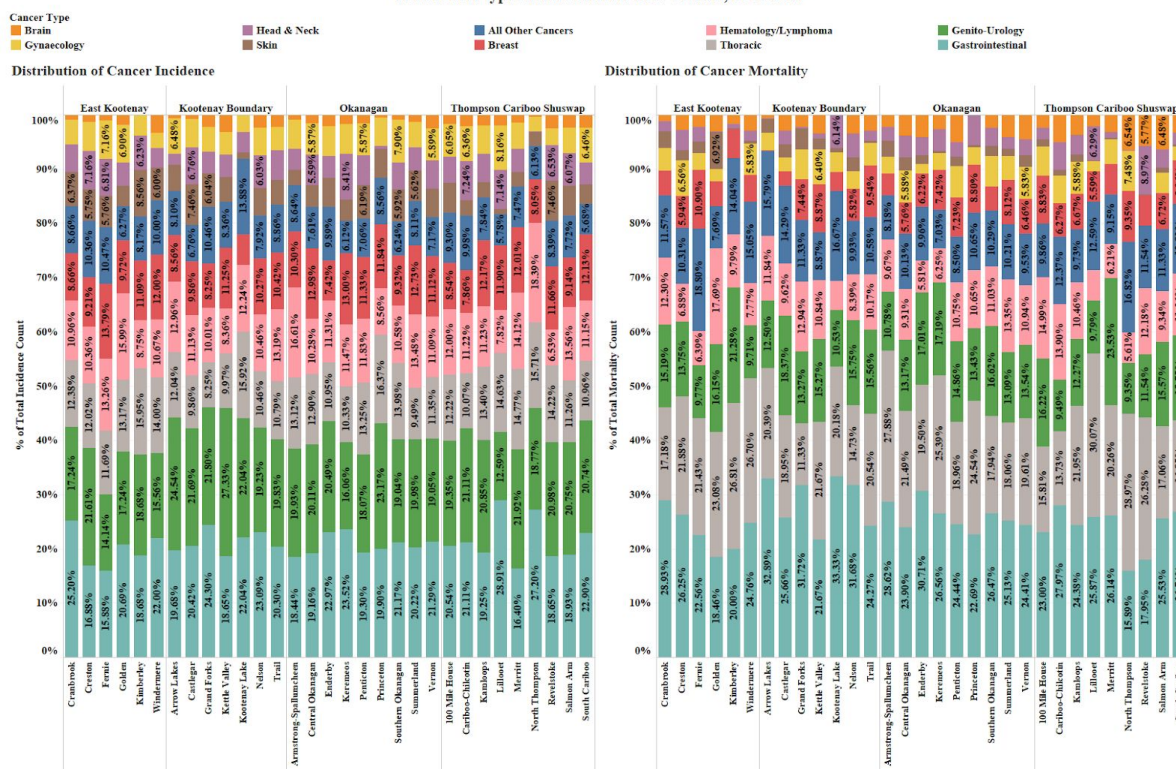
Local Health Area

General Pattern in LHAs

Incidence and mortality distribution of cancer types across all LHAs are similar to that of the HSDAs as a whole. At the LHA level, cancer incidence and mortality counts could be small, resulting in high statistical uncertainty. Still, in most LHAs, the highest incidence was reported for GI and GU cancer types. The highest mortality was reported for GI and thoracic type cancers, also in alignment with what is reported nationally (Canadian Cancer Statistics Advisory Committee, 2019).

(For a detailed % table, please refer to Appendix B.2.1 and B.2.2.)

Figure 2.1.1 Distribution of cancer incidence and cancer mortality counts of 10 cancer types across Interior B.C.'s LHAs, 2012-2016



Differences among LHAs

ANOVA Test Outcomes

In this section, highlight tables of LHAs are presented in the same way as those of HSDAs. The “N/A” was inserted when all values of rate were zeros in the specified LHA. And for the LHA with at least one non-zero rate and more than one zero rates in remaining cells, multiple “lowest” would be inserted.

- *Incidence/Mortality Rates of all LHAs under each Cancer Type in each HSDA*

Table 2.2.1 and Table 2.2.2 visualize the differences in means of incidence and mortality for each cancer type amongst LHAs.

		All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
East Kootenay	Cranbrook	-	-	-	-	-	-	-	-	-	-
	Creston	-	-	-	-	Highest	-	-	-	-	-
	Fernie	-	-	-	-	Lowest	-	-	-	-	-
	Golden	-	-	-	-	-	-	-	-	-	-
	Kimberley	-	-	-	-	-	-	-	-	Highest	-
	Windermere	-	-	-	-	-	-	-	-	-	-
Kootenay Boundary	Arrow Lakes	-	-	-	-	Highest	Highest	-	-	-	-
	Castlegar	-	-	-	-	-	-	-	-	-	-
	Grand Forks	-	-	-	-	-	-	-	-	-	-
	Kettle Valley	-	-	-	-	-	-	-	-	-	-
	Kootenay Lake	-	-	-	-	-	-	-	-	-	Highest
	Nelson	-	-	-	-	Lowest	Lowest	-	-	-	Lowest
Okanagan	Trail	-	-	-	-	-	-	-	-	-	-
	Armstrong-Spallumcheen	-	-	-	-	-	-	-	-	-	-
	Central Okanagan	Lowest	-	Lowest	Lowest	Lowest	-	-	Lowest	Lowest	Lowest
	Enderby	Highest	-	-	-	-	-	-	-	-	-
	Keremeos	-	-	Highest	Highest	-	-	Highest	Highest	-	-
	Penticton	-	-	-	-	-	-	-	-	-	-
Thompson Cariboo Shuswap	Princeton	-	-	-	-	Highest	-	Lowest	-	Highest	Highest
	Southern Okanagan	-	-	-	-	-	-	-	-	-	-
	Summerland	-	-	-	-	-	-	-	-	-	-
	Vernon	-	-	-	-	-	-	-	-	-	-
	100 Mile House	-	-	-	-	-	-	-	-	-	-
	Cariboo-Chilcotin	-	-	Lowest	-	-	-	-	-	-	Lowest
Thompson Cariboo Shuswap	Kamloops	-	-	-	Lowest	-	-	-	-	-	-
	Lillooet	-	-	-	-	-	Highest	-	-	Lowest	Highest
	Merritt	-	-	-	-	-	-	-	-	-	-
	North Thompson	-	-	-	-	-	-	-	Highest	-	-
	Revelstoke	-	-	-	-	-	-	-	-	-	-
	Salmon Arm	-	-	-	-	-	Lowest	-	Lowest	Highest	-
Thompson Cariboo Shuswap	South Cariboo	-	-	Highest	-	-	-	-	-	-	-

		All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
East Kootenay	Cranbrook	-	-	-	-	-	-	-	-	-	-
	Creston	-	-	-	-	-	-	-	-	-	-
	Fernie	-	-	-	-	Lowest	-	-	-	-	-
	Golden	-	-	-	-	-	-	-	-	-	-
	Kimberley	-	-	-	-	Highest	-	-	-	-	-
	Windermere	-	-	-	-	-	-	-	-	-	-
Kootenay Boundary	Arrow Lakes	-	-	-	-	-	-	-	-	-	-
	Castlegar	-	-	-	-	-	-	-	-	-	-
	Grand Forks	-	-	-	-	-	-	-	-	-	-
	Kettle Valley	-	-	-	-	-	-	-	-	-	Highest
	Kootenay Lake	-	-	-	-	-	-	-	-	-	-
	Nelson	-	-	-	-	-	-	-	-	-	Lowest
Okanagan	Trail	-	-	-	-	-	-	-	-	-	-
	Armstrong-Spallumcheen	-	-	-	-	-	-	-	-	-	-
	Central Okanagan	-	-	-	-	Lowest	-	-	-	-	Lowest
	Enderby	-	-	-	-	-	-	-	-	-	-
	Keremeos	-	-	-	-	Highest	-	-	-	-	Highest
	Penticton	-	-	-	-	-	-	-	-	-	-
Thompson Cariboo Shuswap	Princeton	-	-	-	-	-	-	-	-	-	-
	Southern Okanagan	-	-	-	-	-	-	-	-	-	-
	Summerland	-	-	-	-	-	-	-	-	-	-
	Vernon	-	-	-	-	-	-	-	-	-	-
	100 Mile House	-	-	-	-	-	-	-	-	-	-
	Cariboo-Chilcotin	-	-	-	-	-	-	-	-	-	Lowest
Thompson Cariboo Shuswap	Kamloops	-	-	-	-	Lowest	-	-	-	-	-
	Lillooet	-	-	-	-	-	-	-	-	-	Highest
	Merritt	-	-	-	-	Highest	-	-	-	-	-
	North Thompson	-	-	-	-	-	-	-	-	-	-
	Revelstoke	-	-	-	Lowest	-	-	-	-	-	-
	Salmon Arm	-	-	-	-	-	-	-	-	-	-
Thompson Cariboo Shuswap	South Cariboo	-	-	-	Highest	-	-	-	-	-	-

For East Kootenay, GU and skin cancers showed a relatively higher average of incidence rates respectively in Creston and Kimberley, but only GU maintained higher value in the averages for mortality rates in Kimberley. Inversely, Area Fernie hit the bottom for both incidence rate and death rate under cancer GU.

In Kootenay Boundary, GU, gynecology, and thoracic appeared significant differences in the averages for incidence rates, but only thoracic existed a significant difference in the averages for mortality rates. The Nelson area had the lowest incidence rates in both GU and gynecology while the highest rates occurred in the Arrow Lakes area.

For the Okanagan, the Keremeos area appeared to have the highest incidence rate in four cancer types, including breast, GI, head and neck, and hematology/lymphoma cancers; while GU, skin, and thoracic cancer had the highest incidence rate in Princeton. Only GU and thoracic cancer

remain a significant difference in the averages for mortality rates, with the highest rate appeared in the Keremeos area.

In Thompson Cariboo Shuswap, unlike other HSDAs, genito-urology cancers did not show the disparity in the mean of incidence rates amongst LHAs but indicated the highest cancer mortality rate in Merritt. The highest incidence rates for breast, gynecology, and thoracic cancers and the highest mortality rate for genito-urology cancers were reported in Lillooet.

Overall, there were regional differences in the incidence rates and death rates for cancer types amongst LHAs within HSDA from 2012 to 2016. All cancer types, except for brain cancer, showed disparities in the mean of incidence rates amongst LHAs within HSDA. A few cancer types, specifically GU, GI, and thoracic, were found to have disparities in the average mortality rates amongst LHAs within some HSDAs.

- *Incidence/Mortality Rates of all Cancer Types in each LHA*

Tables 2.2.3 and 2.2.4 examined the means of incidence or mortality rates over the years, from 2012 to 2016, amongst all ten cancer types in each LHA. Unlike tables 2.2.1 and 2.2.2, which compared means amongst all LHAs within HSDA by each cancer type instead.

		All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
East Kootenay	Cranbrook		Lowest		Highest						
	Creston					Highest					
	Fernie		Lowest		Highest						
	Golden		Lowest		Highest						
	Kimberley		Lowest			Highest					
	Windermere				Highest		Lowest				
Kootenay Boundary	Arrow Lakes		Lowest			Highest					
	Castlegar		Lowest			Highest					
	Grand Forks		Lowest		Highest						
	Kettle Valley		Lowest			Highest					
	Kootenay Lake		Lowest		Highest						
	Nelson		Lowest		Highest						
	Trail		Lowest		Highest						
Okanagan	Armstrong-Spallumcheen		Lowest			Highest					
	Central Okanagan		Lowest			Highest					
	Enderby		Lowest		Highest						
	Keremeos		Lowest		Highest						
	Penticton		Lowest		Highest						
	Princeton					Highest		Lowest			
	Southern Okanagan		Lowest		Highest						
	Summerland		Lowest		Highest						
	Vernon		Lowest		Highest						
Thompson Cariboo Shuswap	100 Mile House		Lowest		Highest						
	Cariboo-Chilcotin		Lowest			Highest					
	Kamloops		Lowest			Highest					
	Lillooet				Highest						Lowest
	Merritt		Lowest			Highest					
	North Thompson				Highest			Lowest			
	Revelstoke		Lowest			Highest					
	Salmon Arm		Lowest			Highest					
	South Cariboo		Lowest		Highest						

		All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
East Kootenay	Cranbrook		Lowest		Highest					Lowest	
	Creston				Highest						
	Fernie		Lowest		Highest						
	Golden							Lowest			Highest
	Kimberley						Lowest			Lowest	Highest
Kootenay Boundary	Windermere									Lowest	Highest
	Arrow Lakes			Lowest	Highest			Lowest			
	Castlegar				Highest					Lowest	
	Grand Forks				Highest			Lowest			
	Kettle Valley				Highest			Lowest			
	Kootenay Lake		Lowest		Highest						
	Nelson				Highest					Lowest	
Okanagan	Trail				Highest					Lowest	
	Armstrong-Spallumcheen		Lowest		Highest					Lowest	
	Central Okanagan				Highest						
	Enderby				Highest		Lowest				
	Keremeos				Highest					Lowest	
	Penticton				Highest					Lowest	
	Princeton		Lowest								Highest
	Southern Okanagan				Highest					Lowest	
Thompson Cariboo Shuswap	Summerland				Highest					Lowest	
	Vernon				Highest					Lowest	
	100 Mile House				Highest					Lowest	
	Cariboo-Chilcotin				Highest					Lowest	
	Kamloops				Highest					Lowest	
	Lillooet										Highest
	Merritt				Highest					Lowest	
	North Thompson							Lowest		Lowest	Highest
	Revelstoke						Lowest			Lowest	Highest
	Salmon Arm				Highest					Lowest	
	South Cariboo				Highest					Lowest	

Incidence and mortality distribution of cancer types in LHAs are overall consistent with that of the HSDAs and Interior Health Region. The highest incidence rate still observed for GI and GU cancers and the highest mortality rate still observed for GI and thoracic cancers. Cancer types that had the lowest incidence rate and death rate by LHAs were brain cancer and skin cancer separately. As the brain cancer is hard to detect by diagnostic modalities at the current phase with no obvious symptoms in the early stage, it had the lowest incidence rate (Canadian Cancer Statistics Advisory Committee, 2019). Since the most cases of skin cancer in Canada are basal and squamous cell carcinomas, which develop slowly and do not spread to other parts of the body as well, so the skin cancer had the lowest mortality rate as most patients can be cured by surgery (“Skin cancer,” 2018).

- *Incidence/Mortality Rates of all Cancer Types under each Age Group and each LHA*

Considering age effect, we tested if there exist significant differences in means of incidence and death rates over five years, amongst ten cancer types in each LHA within HSDAs, and under each age group. Again, “N/A” was inserted when all values of rate were zeros for the LHA under the specified age group. And for the LHA in the age group with at least one non-zero rate and more than one zero rate in remaining cells, multiple “lowest” would be inserted.

Tables 2.2.5 to 2.2.12 are compared to Table 1.2.5 and 1.2.6 to detect differences between LHAs and their corresponding HSDAs, with age taken into consideration.

○ *East Kootenay*

			All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
East Kootenay	15-29	Cranbrook	-	-	-	-	-	-	-	-	-	-
		Creston	-	-	-	-	-	-	-	-	-	-
		Fernie	-	-	-	-	-	-	-	-	-	-
		Golden	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Kimberley	-	-	-	-	-	-	-	-	-	-
		Windermere	-	-	-	-	-	-	-	-	-	-
	30-49	Cranbrook	-	-	-	-	-	-	-	-	-	-
		Creston	-	-	-	-	-	-	-	-	-	-
		Fernie	-	-	-	-	-	-	-	-	-	-
		Golden	-	Lowest	Highest	-	-	Lowest	-	-	Lowest	Lowest
		Kimberley	-	-	-	-	-	-	-	-	-	-
		Windermere	-	-	-	-	-	-	-	-	-	-
	50-69	Cranbrook	-	Lowest	-	Highest	-	-	-	-	-	-
		Creston	-	Lowest	-	-	Highest	Highest	-	-	-	-
		Fernie	-	-	-	-	-	-	-	-	Lowest	-
		Golden	-	Lowest	-	Highest	-	-	-	-	-	-
		Kimberley	-	Lowest	-	-	-	-	-	-	-	Highest
		Windermere	-	-	-	Highest	-	Lowest	-	-	-	-
	70-84	Cranbrook	-	Lowest	-	Highest	-	-	-	-	-	-
		Creston	-	Lowest	-	-	Highest	-	-	-	-	-
		Fernie	-	Lowest	-	Highest	-	-	-	-	-	-
		Golden	-	-	-	-	-	-	Lowest	-	-	Highest
		Kimberley	-	Lowest	-	-	Highest	Lowest	-	-	-	-
		Windermere	-	-	-	Highest	-	-	Lowest	-	-	-
	85+	Cranbrook	-	Lowest	-	Highest	-	-	-	-	-	-
		Creston	-	-	-	-	-	-	-	-	-	-
		Fernie	-	-	-	-	-	-	-	-	-	-
		Golden	Lowest	Lowest	-	-	-	Lowest	Lowest	Highest	Lowest	-
		Kimberley	-	Lowest	-	Highest	-	Lowest	-	-	-	-
		Windermere	-	-	-	-	-	-	-	-	-	-

			All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
East Kootenay	15-29	Cranbrook	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Creston	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Fernie	-	-	-	-	-	-	-	-	-	-
		Golden	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Kimberley	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Windermere	-	-	-	-	-	-	-	-	-	-
	30-49	Cranbrook	-	-	-	-	-	-	-	-	-	-
		Creston	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Fernie	Highest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest
		Golden	-	-	-	-	-	-	-	-	-	-
		Kimberley	-	-	-	-	-	-	-	-	-	-
		Windermere	-	-	-	-	-	-	-	-	-	-
	50-69	Cranbrook	-	Lowest	-	Highest	-	-	-	-	-	-
		Creston	-	-	-	Highest	-	-	-	-	Lowest	-
		Fernie	-	-	-	Highest	-	-	-	-	Lowest	-
		Golden	-	-	-	-	-	-	-	-	-	-
		Kimberley	-	-	-	Highest	Lowest	Lowest	-	-	Lowest	Highest
		Windermere	-	-	-	Highest	-	-	Lowest	-	-	-
	70-84	Cranbrook	-	-	-	Highest	-	-	-	-	-	-
		Creston	-	Lowest	-	Highest	-	-	Lowest	-	Lowest	-
		Fernie	-	Lowest	-	-	-	-	-	-	-	Highest
		Golden	-	-	-	-	-	-	-	-	-	-
		Kimberley	-	Lowest	-	-	-	Lowest	-	-	Lowest	Highest
		Windermere	-	-	-	-	-	-	-	-	-	-
	85+	Cranbrook	-	Lowest	Lowest	Highest	-	-	Lowest	-	-	-
		Creston	-	Lowest	-	-	Highest	Lowest	-	-	-	-
		Fernie	-	-	-	-	-	-	-	-	-	-
		Golden	Lowest	Lowest	-	-	Highest	Lowest	Lowest	-	-	-
		Kimberley	-	Lowest	-	-	Highest	Lowest	Lowest	-	Lowest	-
		Windermere	-	-	-	-	-	-	-	-	-	-

In East Kootenay, under age group 30-49, only area Golden showed a considerable difference of means amongst ten cancer types for incidence rates, while only area Fernie had a significant difference in mortality rates. Kimberly and Golden LHAs had the highest incidence rate in thoracic cancer under age 70-84, however, East Kootenay HSDA showed the highest incidence rate in GU for this age group. The Golden area had the highest incidence rate in hematology/lymphoma cancer for people aged 85+, but East Kootenay HSDA showed the highest incidence rate in GI cancer in this age group.

○ *Kootenay Boundary*

			All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
Kootenay Boundary	15-29	Arrow Lakes	-	-	-	-	-	-	-	-	-	-
		Castlegar	-	-	-	-	-	-	-	-	-	-
		Grand Forks	-	-	-	-	-	-	-	-	-	-
		Kettle Valley	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Kootenay Lake	Highest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest
		Nelson	-	-	-	-	-	-	-	-	-	-
		Trail	-	-	-	-	-	-	-	-	-	-
	30-49	Arrow Lakes	-	-	-	-	-	-	-	-	-	-
		Castlegar	-	-	-	-	-	-	-	-	-	-
		Grand Forks	-	-	-	-	-	-	-	-	-	-
		Kettle Valley	-	-	-	-	-	-	-	-	-	-
		Kootenay Lake	-	-	-	-	-	-	-	-	-	-
		Nelson	-	-	-	-	-	-	-	-	-	-
		Trail	Lowest	Lowest	Highest	-	-	-	-	-	-	-
	50-69	Arrow Lakes	-	Lowest	-	-	Highest	-	-	-	-	-
		Castlegar	-	Lowest	-	-	Highest	-	-	-	-	-
		Grand Forks	-	Lowest	-	Highest	-	-	-	-	-	-
		Kettle Valley	-	Lowest	-	-	Highest	-	-	-	-	-
		Kootenay Lake	-	Lowest	-	Highest	-	-	-	-	-	-
		Nelson	-	Lowest	-	Highest	-	-	-	-	-	-
		Trail	-	Lowest	-	-	Highest	-	-	-	-	-
	70-84	Arrow Lakes	-	Lowest	-	-	Highest	-	-	-	-	-
		Castlegar	-	Lowest	-	-	Highest	-	-	-	-	-
		Grand Forks	-	Lowest	-	Highest	-	-	-	-	-	-
		Kettle Valley	-	-	-	-	Highest	Lowest	-	-	-	-
		Kootenay Lake	-	Lowest	-	-	Highest	-	-	-	Lowest	-
		Nelson	-	Lowest	-	Highest	-	-	-	-	-	-
		Trail	-	-	-	Highest	-	Lowest	-	-	-	-
	85+	Arrow Lakes	-	Lowest	Lowest	-	Highest	Lowest	Lowest	-	Lowest	-
		Castlegar	-	Lowest	-	Highest	-	-	-	-	Lowest	-
		Grand Forks	-	-	-	-	-	-	-	-	-	-
		Kettle Valley	-	-	-	-	-	-	-	-	-	-
		Kootenay Lake	-	-	-	-	-	-	-	-	-	-
		Nelson	-	Lowest	-	Highest	-	-	-	-	-	-
		Trail	-	-	-	Highest	-	-	-	-	Lowest	-

			All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
Kootenay Boundary	15-29	Arrow Lakes	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Castlegar	-	-	-	-	-	-	-	-	-	-
		Grand Forks	-	-	-	-	-	-	-	-	-	-
		Kettle Valley	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Kootenay Lake	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Nelson	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Trail	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30-49	Arrow Lakes	-	-	-	-	-	-	-	-	-	-
		Castlegar	Lowest	Lowest	-	Highest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest
		Grand Forks	-	-	-	-	-	-	-	-	-	-
		Kettle Valley	-	-	-	-	-	-	-	-	-	-
		Kootenay Lake	-	-	-	-	-	-	-	-	-	-
		Nelson	Lowest	-	Lowest	-	Lowest	Lowest	Lowest	-	Lowest	Highest
		Trail	-	-	-	-	-	-	-	-	-	-
	50-69	Arrow Lakes	-	-	Lowest	Highest	-	-	Lowest	-	-	-
		Castlegar	-	-	Lowest	Highest	-	-	-	-	-	-
		Grand Forks	-	-	-	Highest	-	-	Lowest	-	-	-
		Kettle Valley	-	-	-	Highest	-	-	Lowest	-	-	-
		Kootenay Lake	-	Lowest	-	-	-	Lowest	-	-	-	Highest
		Nelson	-	-	-	Highest	-	-	-	-	Lowest	-
		Trail	-	-	-	-	-	-	-	-	Lowest	Highest
	70-84	Arrow Lakes	-	Lowest	Lowest	Highest	-	-	Lowest	-	Lowest	-
		Castlegar	-	-	-	Highest	-	-	-	-	-	-
		Grand Forks	-	-	-	Highest	-	-	Lowest	-	-	-
		Kettle Valley	-	-	-	-	-	-	-	-	-	-
		Kootenay Lake	-	-	-	-	-	-	-	-	-	-
		Nelson	-	-	-	Highest	-	-	-	-	Lowest	-
		Trail	-	-	-	Highest	-	-	-	-	Lowest	-
	85+	Arrow Lakes	-	-	-	-	-	-	-	-	-	-
		Castlegar	-	Lowest	-	-	Highest	Lowest	Lowest	-	Lowest	-
		Grand Forks	-	Lowest	Lowest	-	-	-	-	-	-	-
		Kettle Valley	-	-	-	Highest	-	-	-	-	-	-
		Kootenay Lake	Lowest	Lowest	-	Highest	-	Lowest	Lowest	Lowest	Lowest	Lowest
		Nelson	-	-	-	-	Highest	-	-	-	-	-
		Trail	-	-	-	Highest	-	Lowest	Lowest	-	Lowest	-

In Kootenay Boundary, only the Kootenay Lake area showed significant differences in the averages amongst ten cancer types for incidence rates under age group 15-29. Under age group 85+, although Kootenay Boundary HSDA showed the highest mortality rate in GI cancer, cancer mortality rates in Castlegar and Nelson areas were indicated highest in GU cancer.

○ Okanagan

			All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
Okanagan	15-29	Armstrong-Spallumcheen	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Central Okanagan	-	-	Lowest	-	-	-	-	Highest	-	-
		Enderby	-	-	-	-	-	-	-	-	-	-
		Keremeos	-	-	-	-	-	-	-	-	-	-
		Penticton	-	-	-	-	-	-	-	-	-	-
		Princeton	-	-	-	-	-	-	-	-	-	-
		Southern Okanagan	-	-	-	-	-	-	-	-	-	-
		Summerland	-	-	-	-	-	-	-	-	-	-
		Vernon	-	-	-	-	-	-	-	-	-	-
	30-49	Armstrong-Spallumcheen	-	-	-	-	-	-	-	-	-	-
		Central Okanagan	-	Lowest	Highest	-	-	-	-	-	-	-
		Enderby	-	-	-	-	-	-	-	-	-	-
		Keremeos	Lowest	-	-	Highest	Lowest	-	Lowest	Lowest	Lowest	Lowest
		Penticton	-	-	Highest	-	-	-	-	-	-	-
		Princeton	-	-	-	-	-	-	-	-	-	-
		Southern Okanagan	-	-	-	-	-	-	-	-	-	-
		Summerland	-	-	Highest	-	-	Lowest	-	-	-	-
		Vernon	-	-	-	-	-	-	-	-	-	-
	50-69	Armstrong-Spallumcheen	-	Lowest	-	-	Highest	-	-	-	-	-
		Central Okanagan	-	Lowest	-	-	Highest	-	-	-	-	-
		Enderby	-	Lowest	-	Highest	-	-	-	-	-	-
		Keremeos	-	Lowest	-	Highest	-	-	-	-	-	-
		Penticton	-	Lowest	-	Highest	-	-	-	-	-	-
		Princeton	-	-	-	-	Highest	-	Lowest	-	-	-
		Southern Okanagan	-	Lowest	-	Highest	-	-	-	-	-	-
		Summerland	-	Lowest	-	Highest	-	-	-	-	-	-
		Vernon	-	Lowest	-	Highest	-	-	-	-	-	-
	70-84	Armstrong-Spallumcheen	-	Lowest	-	-	Highest	Lowest	-	-	-	-
		Central Okanagan	-	Lowest	-	-	Highest	-	-	-	-	-
		Enderby	-	Lowest	-	Highest	-	-	-	-	-	-
		Keremeos	-	Lowest	-	Highest	-	-	-	-	-	-
		Penticton	-	Lowest	-	Highest	-	-	Lowest	-	-	-
		Princeton	-	Lowest	-	-	Highest	-	-	-	-	-
		Southern Okanagan	-	Lowest	-	Highest	-	-	-	-	-	-
		Summerland	-	Lowest	-	Highest	-	-	-	-	-	-
		Vernon	-	Lowest	-	Highest	-	-	-	-	-	-
	85+	Armstrong-Spallumcheen	-	Lowest	-	-	-	-	Lowest	-	Lowest	Highest
		Central Okanagan	-	Lowest	-	Highest	-	-	Lowest	-	Lowest	Highest
		Enderby	-	Lowest	-	-	-	Lowest	Lowest	-	-	-
		Keremeos	Lowest	Lowest	-	-	-	-	-	-	-	-
		Penticton	-	Lowest	-	-	Highest	-	-	-	-	-
		Princeton	-	-	-	-	-	-	-	-	-	-
		Southern Okanagan	-	Lowest	-	-	Highest	-	-	-	-	-
		Summerland	-	Lowest	-	Highest	-	-	-	-	-	-
		Vernon	-	Lowest	-	Highest	-	-	-	-	-	-

			All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
Okanagan	15-29	Armstrong-Spallumcheen	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Central Okanagan	-	-	-	-	-	-	-	-	-	-
		Enderby	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Keremeos	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Penticton	-	-	-	-	-	-	-	-	-	-
		Princeton	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Southern Okanagan	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Summerland	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Vernon	-	-	-	-	-	-	-	-	-	-
	30-49	Armstrong-Spallumcheen	-	-	-	-	-	-	-	-	-	-
		Central Okanagan	-	-	-	-	-	-	-	-	-	-
		Enderby	-	-	-	-	-	-	-	-	-	-
		Keremeos	-	-	-	-	-	-	-	-	-	-
		Penticton	-	-	-	-	-	-	-	-	-	-
		Princeton	-	-	-	-	-	-	-	-	-	-
		Southern Okanagan	-	-	-	-	-	-	-	-	-	-
		Summerland	Lowest	Highest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest
		Vernon	-	-	-	-	-	-	-	-	-	-
	50-69	Armstrong-Spallumcheen	-	-	-	Highest	-	-	-	-	Lowest	Highest
		Central Okanagan	-	-	-	Highest	-	-	-	Lowest	Lowest	-
		Enderby	-	-	-	Highest	-	-	-	-	Lowest	-
		Keremeos	-	-	-	Highest	-	-	-	-	Lowest	-
		Penticton	-	Lowest	-	-	Lowest	-	-	-	Lowest	Highest
		Princeton	-	-	-	-	-	-	-	-	Lowest	-
		Southern Okanagan	-	-	-	Highest	-	-	-	-	Lowest	-
		Summerland	-	-	-	Highest	-	-	Lowest	-	Lowest	-
		Vernon	-	-	-	-	-	-	-	-	-	-
	70-84	Armstrong-Spallumcheen	-	-	-	-	-	-	Lowest	-	Lowest	Highest
		Central Okanagan	-	-	-	-	Highest	Lowest	-	-	Lowest	-
		Enderby	-	Lowest	-	Highest	-	-	-	-	Lowest	-
		Keremeos	-	-	-	Highest	-	-	-	-	Lowest	Highest
		Penticton	-	Lowest	-	-	-	-	Lowest	-	Lowest	Highest
		Princeton	-	-	-	-	-	-	-	-	Lowest	-
		Southern Okanagan	-	-	-	Highest	-	-	-	-	Lowest	Highest
		Summerland	-	-	-	-	-	-	Lowest	-	Lowest	Highest
		Vernon	-	-	-	-	-	-	-	-	-	-
	85+	Armstrong-Spallumcheen	-	Lowest	Lowest	Highest	-	-	-	-	Lowest	-
		Central Okanagan	-	-	-	Highest	-	-	-	-	Lowest	-
		Enderby	-	-	-	-	-	Lowest	Lowest	-	Lowest	-
		Keremeos	Lowest	Lowest	-	-	-	-	-	-	Lowest	Highest
		Penticton	-	Lowest	-	-	Highest	-	-	-	-	-
		Princeton	-	-	Lowest	Highest	-	-	Lowest	-	-	-
		Southern Okanagan	-	Lowest	-	-	Highest	-	-	-	-	-
		Summerland	-	Lowest	-	Highest	-	-	-	-	Lowest	-
		Vernon	-	Lowest	-	Highest	-	-	-	-	Lowest	-

[illegible]

		All Other Cancers	Brain	Breast	Gastrointestinal	Genito-Urology	Gynaecology	Head & Neck	Hematology/Lymphoma	Skin	Thoracic
Thompson Cariboo Shuswap	15-29	100 Mile House	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Cariboo-Chilcotin	-	-	-	-	-	-	-	-	-
		Kamloops	Lowest	Highest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest	Lowest
		Lilloet	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Merritt	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		North Thompson	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Revelstoke	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Salmon Arm	-	-	-	-	-	-	-	-	-
		South Cariboo	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
	30-49	100 Mile House	-	-	-	-	-	-	-	-	-
		Cariboo-Chilcotin	-	-	-	Highest	Lowest	-	Lowest	Lowest	-
		Kamloops	-	-	-	-	-	-	-	-	-
		Lilloet	-	-	-	-	-	-	-	-	-
		Merritt	-	-	-	-	-	-	-	-	-
		North Thompson	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
		Revelstoke	-	-	-	-	-	-	-	-	-
		Salmon Arm	-	-	-	-	-	-	-	-	-
		South Cariboo	-	-	-	-	-	-	-	-	-
	50-69	100 Mile House	-	-	-	Highest	-	Lowest	-	-	-
		Cariboo-Chilcotin	-	-	-	Highest	-	-	-	Lowest	-
		Kamloops	-	-	-	Highest	-	-	-	Lowest	-
		Lilloet	-	-	-	Highest	-	-	-	Lowest	-
		Merritt	-	-	Lowest	Highest	-	-	-	Lowest	-
		North Thompson	-	-	-	-	-	-	-	-	-
		Revelstoke	-	-	-	-	-	-	-	-	-
		Salmon Arm	-	-	-	Highest	-	-	-	Lowest	-
		South Cariboo	-	-	-	Highest	-	-	-	Lowest	-
	70-84	100 Mile House	-	-	-	Highest	-	-	-	Lowest	-
		Cariboo-Chilcotin	-	-	-	Highest	-	-	-	Lowest	-
		Kamloops	-	-	-	-	-	Lowest	-	Lowest	Highest
		Lilloet	-	Lowest	Lowest	-	-	-	Lowest	Lowest	-
		Merritt	-	-	-	Highest	-	-	-	Lowest	-
		North Thompson	-	-	-	-	-	-	-	-	-
		Revelstoke	-	-	Lowest	-	Lowest	-	-	Lowest	Highest
		Salmon Arm	-	-	-	Highest	-	-	-	Lowest	-
		South Cariboo	-	Lowest	-	Highest	-	-	-	Lowest	-
	85+	100 Mile House	-	Lowest	-	Highest	Lowest	-	-	Lowest	-
		Cariboo-Chilcotin	-	Lowest	-	Highest	-	Lowest	-	Lowest	-
		Kamloops	-	-	-	Highest	-	-	-	Lowest	-
		Lilloet	-	-	-	-	-	-	-	-	-
		Merritt	-	-	-	-	-	-	-	-	-
		North Thompson	-	-	-	-	-	-	-	-	-
		Revelstoke	-	-	-	-	-	-	-	-	-
		Salmon Arm	-	-	-	Highest	-	-	-	Lowest	-
		South Cariboo	-	Lowest	-	Highest	Lowest	Lowest	Lowest	Lowest	-

In Thompson Cariboo Shuswap, area Kamloops presented significantly different incidence rates amongst cancer types, with hematology/lymphoma cancer being the highest in the age group 15-29. Even though Thompson Cariboo Shuswap HSDA displayed the highest incidence rate in hematology/lymphoma cancer for the age group 30-49, 100 Mile House and Kamloops LHAs the highest incidence rate taking place in GI and breast respectively. Furthermore, Thompson Cariboo Shuswap HSDA was discovered to have the highest mortality rate in GI for patients aged 30-85+, however, for patients aged 70-84 in Merritt and aged 85+ in 100 Mile House and South Cariboo, the highest mortality rate was reported as GU cancer.

Generally, some LHAs had dissimilar performance in incidence/mortality to their HSDAs with age taking into consideration.

Conclusion

To summarize, the overall goal for this project was to explore if there exists any geographical disparity for cancer outcomes across HSDAs and LHAs in the Interior Health region. Specifically, our objectives included three parts: the first one is to examine differences in incidence and mortality regards to the distribution of cancer types, the second one is to detect

differences in cancer incidence and mortality by cancer type amongst HSDAs and LHAs, and the third one is to investigate how incidence and mortality change by ten cancer types across each HSDA and LHA considering age groups or not. In this section, we will conclude the answers to the research question, difficulties encountered, limitations, and prospects.

Summary

According to our research, differences between regions can be answered at the HSDA level and LHA level respectively.

HSDA level:

- No apparent disparities amongst regions were found regarding the distribution of cancer types amongst HSDAs.
- Across the ten cancer types, differences were found across regions for cancer incidence and mortality. Amongst all HSDAs, Kootenay Boundary had the highest incidence rates for 4 types of cancer: all other cancers, GI, GU, and skin cancers. All of them except for the skin cancer resulted in the highest mortality rates.
 - Although rates of diagnosed cases of breast cancer were similar to that of the other three regions, Kootenay Boundary had the highest mortality rates of that cancer due to the lowest breast cancer screening participation.
- If the age is considered, we observed some differences to the general pattern of other HSDAs in certain age groups.
 - For incidence rates, in age group 15-29, hematology/lymphoma cancer had the highest incidence rates in Okanagan and Thompson Cariboo Shuswap. In age groups 30-49, breast cancer had the most occurrence in East Kootenay and Okanagan, in Thompson Cariboo Shuswap, however, more patients suffered hematology/lymphoma cancer.
 - For mortality rates in the age range of 70 to 84, cancer mortality was highest in the Okanagan for thoracic cancer, and highest in East Kootenay for GU.

LHA level:

- Incidence and mortality distribution of cancer types in LHAs are overall consistent with that of the HSDAs and Interior Health Region.
 - The highest incidence rate still observed for GI and GU cancers and the highest mortality rate still observed for GI and thoracic cancers.
 - Cancer types that had the lowest incidence rate and death rate by LHAs were brain cancer and skin cancer separately.
- There were regional differences in the incidence rates and death rates for cancer types amongst LHAs within HSDA from 2012 to 2016.

-
- All cancer types, except for brain cancer, showed disparities in the mean of incidence rates amongst LHAs within HSDA.
 - A few cancer types, specifically GU, GI, and thoracic, were found to have disparities in the average mortality rates amongst LHAs within some HSDA
 - Some LHAs had dissimilar performance in incidence/mortality to their HSDAs with age taking into consideration.
 - For instance, the Golden area in East Kootenay reported the highest incidence rate in hematology/lymphoma cancer for people aged 85+, but East Kootenay HSDA found the highest incidence rate in GI cancer in the same age group.

Difficulties Encountered

Throughout our research, we've encountered barriers as following:

- Many incidences or mortality counts in the original dataset were collected as the categorical variables.
 - Solution: we replaced all '<5' by a number that was randomly selected from 1 to 4 through the uniform distribution.
- Initially, there were 24 cancer types and 16 age groups. Lots of categories result in numerous 0 counts, making the output of chi-square tests inaccurate.
 - Solution: we merged several groups to form ten cancer types and five age groups in data preparation.

Limitations

After reviewing the entire study, we found a few uncertainties:

- As mentioned above, the categorical variable '<5' was replaced by a number randomly selected by the uniform distribution, which may deviate from reality.
- Fewer data existed in the LHA level and the young-age level, which probably leads to high statistical uncertainty and interpretation of this data, should be cautioned.

Potential Future Directions

Based on our research, the following aspects can be explored in further analysis.

- Explore the effect of access to other health services and life-styles by region.
- Conduct a statistical significance test (Student's t-test) to find the correlated health characteristics that hold for the population.

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Appendix A - Description Tables

For the values of counts, the means were round to integers and the standard deviations were round to two decimal places.

A1. HSDA Description Table

A2. LHA Description Tables

Appendix B - Distribution Tables

Gold color: The most commonly diagnosed cancers/ the most common cause of cancers of death

Silver color: The second common diagnosed cancers/ the second most common cancers cause of death

Bronze color: The third common diagnosed cancers/ the third most common cancers cause of death

B1. HSDA Distribution Tables

B2. LHA Distribution Tables

(The tables in Appendix were removed due to the data only share internally within BC Cancer)