CANCER INCIDENCE BY IMMIGRANT STATUS

IN BRITISH COLUMBIA

by

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Abstract

Introduction

Cancer differentially affects populations and geographical regions. Given the ethnic diversity and growing population of immigrants in Canada and British Columbia in particular, it is important to understand how the risk of cancer is distributed according to where in BC immigrants live, given that this population may experience distinct cancer risks.

Objectives

The purpose of this study is to understand how cancer incidence rates in BC vary by the regional proportion of immigrants and to explore how these rates are associated with duration of residence (recent versus well established), age at immigration, and country of origin.

Methods

Analyses were conducted using a dataset of adult incident cancers diagnosed in BC (2000 to 2009) collected by the BC Cancer Registry. Regional-level estimates of the proportion of immigrants, as well as the socioeconomic and ethnic profiles of the BC population, were obtained from the Statistics Canada 2006 Census (defined by Local Health Area) and linked to the Cancer Registry data. Poisson and Negative Binomial regression models were used to estimate the rate ratios (RR) of cancer incidence by proportion of immigrants.

Results

Overall, regional immigrant density significantly predicted lower cancer incidence rates for all-cancers and the most common cancers of the breast, prostate, colon and lung. However, for less common cancers of the liver, stomach and pharynx, proportion of immigrants significantly predicted higher cancer risk. This association was seen for recent and established immigrants, although cancer rates were higher among established immigrants. The proportion of immigrants at a younger age at immigration and from European origin were associated with increased risk for all-cancers and common cancers, but decreased risk of less common cancers. The proportion of immigrants at an older age at arrival (particularly 45 years and older) and from Asian origin were associated with decreased all-cancer risk and the risk of common cancers, but increased risk of less common cancers.

Conclusion

Regional-level concentration of immigrants predicted cancer incidence rates in BC. Regional data on cancer incidence is important for developing effective health promotion strategies and public health planning by various Local Health Areas and health authorities in BC.

Preface

This study was reviewed and approved by the University of British Columbia Behavioural Research Ethics Board (certificate #H14-01002). The research described in this thesis was conceived and conducted by Kimberly Burrus under the supervision and guidance of the thesis supervisory committee. This research has not been partly or wholly published.

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List of Abbreviations

BC	British Columbia
BCCR	BC Cancer Registry
BMI	Body Mass Index
HSDA	Health Service Delivery Area
LHA	Local Health Area
SES	Socioeconomic Status

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Chapter 1: Introduction

1.1 Cancer Statistics in Canada

Cancer is a major threat to global public health. In Canada, approximately 196,900 new cancer cases will be diagnosed (excluding non-melanoma skin cancers) and 78,000 deaths will occur in 2015 (Canadian Cancer Society, 2015). It is estimated that 2 in 5 Canadians will develop cancer in their lifetime and 1 in 4 will die of cancer. Surpassing cardiovascular disease as the leading cause of death in Canada, cancer accounts for approximately 30% of all deaths (Canadian Cancer Society, 2015; Statistics Canada, 2012). Within British Columbia (BC), approximately 25,400 new cancer cases will be diagnosed and 10,100 deaths will occur in 2015 (Canadian Cancer Society, 2015). The economic costs generated by cancer are greater than any other disease (World Health Organization, 2008). Not only is the financial strain on the Canadian health care system substantial, but there is also a burden of disease on individuals and society. Cancer diagnosis and treatment is often associated with long-term negative impacts, both physical and psychosocial, and may lead to reduced quality of life for not only the cancer survivor, but also their families and caregivers.

Although people of all ages are affected by cancer, the risk of cancer increases with age and on average, more men than women are diagnosed with cancer (Canadian Cancer Society, 2015). The rising incidence of cancer over the past 30 years is largely due to a growing population and an increasing number of aging persons within the population. The most common cancers diagnosed in Canada and BC are lung, breast, colorectal, and prostate cancer, representing more than half (52%) of all new cancer cases and approximately half of all cancer deaths. For both men and women, lung cancer is the leading cause of cancer death.

At least 50% of cancers can be prevented through reducing risk factors and modifying lifestyle behaviours, including improving diet and nutrition (e.g., increasing fruit and vegetable intake), increasing levels of physical activity, weight control, reducing exposure to the sun and infectious agents (e.g., Human papillomaviruses, Hepatitis viruses B and C), and reducing tobacco and alcohol use (Gotay, 2010; Colditz, Sellers, & Trapido, 2006). Overall, there tends to be poor understanding of cancer risk and preventability among the general public, including Canadians (e.g., Canadian Partnership Against Cancer, 2010; Forbes et al., 2013). This lack of knowledge and understanding about cancer, risk factors and preventability, as well as the availability of screening programs or other health services may be exacerbated when coupled with potential language barriers and reduced health literacy among sub-populations, particularly recent immigrants (McDonald & Kennedy, 2004). Cancer prevention efforts and intervention approaches targeting these modifiable risk factors are important in reducing the cancer burden in the population, especially groups who may be at a higher risk of cancer due to exposures and lifestyles associated with their regional origin.

1.2 Variations in Cancer by Region

The burden of cancer differs across areas of the world and there are disparities in cancer rates and risks across different subgroups and regions. Cancers that are common in Canada may be less common in other countries as there are striking regional variations in cancer by type (World Health Organization, 2008). When comparing the incidence and mortality rates of the most common cancers in more-developed[1] and less-developed countries, the incidence of breast (females), prostate and colorectal cancers is higher in more-developed regions, whereas cancers of the cervix, liver, stomach and esophagus have higher incidence and mortality rates in less-developed regions (World Health Organization, 2008; Ferlay et al., 2013; Wang, Wei, Liu, Li, & Wang, 2012). Furthermore, of the total number of cancer cases and deaths worldwide, the proportion of cancer cases (14.5%) and deaths (9.4%) occurring in the population in North

[1] More developed countries include Europe, North America, Australia/New Zealand, and Japan

America is lower than those in Europe (18.7% and 17.1% respectively) and China (20.2% and 23.8% respectively) (World Health Organization, 2008).

It is evident that there are disparities in cancer across regions of the world and people from certain ethnic origins may have a higher risk of some types of cancer. The racial and ethnic disparities in cancer morbidity and mortality cannot simply be explained by differences in observable socioeconomic factors such as education and income. Global cancer rates are increasing in not only low and middle-income countries, but high-income countries as well (World Cancer Research Fund/American Institute for Cancer Research, 2007). People from certain ethnic groups and less developed rural geographic regions tend to be less healthy and experience a higher risk of some cancers (World Health Organization, 2008). This strikes an interesting question regarding what happens to the cancer risk when people migrate from a particular country of origin to a new country of destination.

Early ecological research examining migrant populations suggested associations between cancer rates and environmental factors, such as nutrition and physical activity, highlighting the primary causes of cancer were environmental rather than genetic (World Cancer Research Fund/American Institute for Cancer Research, 2007). Several studies in the early 1980s that examined populations migrating from their native countries to new countries of residence demonstrate how the rate of cancers tends to approach that of those in the host country. For instance, in a study of female Japanese immigrants to Hawaii, the incidence of breast and colorectal cancers increased dramatically in first generation migrants and continued to increase in second generation migrants for breast cancer, whereas rates of stomach cancer incidence declined in first and second generations (Kolonel, Hinds, & Hankin, 1980). Among Iranian immigrants to Canada, rates of breast and colorectal cancers increased in women and rates of prostate cancer increased in men, yet a striking decrease in rates of stomach and esophageal cancers was seen among both men and women (Yavari et al., 2006). Similar trends of heightened breast and colorectal cancer rates are seen among Polish (Nelson, 2006), Japanese, Chinese, and Filipino (Flood et al., 2000) migrants to the USA. This body of research demonstrates that cancer incidence rates among immigrant populations tend to become more similar to the native-born population with increasing time in the host country, particularly among subsequent generations of immigrants.

1.3 A Focus on Immigrants

A population of particular interest is immigrants in BC. After Ontario, BC has the second highest proportion (27.5%) of foreign-born people in Canada, and recent immigrants account for approximately 4.4% of BC's population (Ip, 2008). Immigrants to BC represent a culturally and racially diverse population, with the diversity varying widely across regions and communities within the province. Although migrants arrive from all areas of the world, trends in region of birth have changed over time as more recent immigrants are arriving from Asia and the Middle East rather than Europe (Statistics Canada, 2007). These changing trends in immigrants' origins are important to consider in relation to overall health status and cancer risk in BC, given that different countries of origin often vary in health-related risk factors and exposures.

Compared with native-born Canadians, immigrants often exhibit differences in their health status and determinants of health, including social determinants, health beliefs and practices, and health services, all of which have implications for their health, including their risk of cancer and other chronic diseases (De Maio, 2010; Gushulak et al., 2011; Canadian Partnership Against Cancer, 2014). Although new immigrants tend to be healthier compared to native-born Canadians when they arrive, a phenomenon known as the "*healthy immigrant effect",* their health status declines over time, putting them at greater risk for ill health and developing chronic conditions such as cancer (see Hyman, 2007 and De Maio, 2010 for reviews of the Canadian literature). This effect has also been observed in other major immigrant-receiving countries such as Australia (e.g., Biddle, Kennedy, & McDonald, 2007; Donovan, d'Espaignet, Merton, & van Ommeren, 1992) and the United

States (e.g., Frisbie, Youngtae, & Hummer, 2001; Stephen, Foote, Hendershot, & Schoenborn, 1994). However, the healthy immigrant effect is not true for all chronic diseases or across all types of cancers, nor is the cancer risk equivalent for all immigrants. The immigrant population represents a heterogeneous group of individuals, differing in age, ethnicity, lifestyle, and many other factors, including immigrant status-related influences. Immigrant populations may experience disparities in cancer rates and outcomes due to a number of reasons, including their ethnic country of origin, age at the time of immigration, length of time since immigration, visible minority status, socioeconomic factors, and barriers in cancer control and access to culturally and linguistically appropriate healthcare services.

Addressing potential inequalities in cancer risk among immigrants and ethnic minorities in Canada is important, as Canada is a major immigrant-receiving country, with the majority of immigrants remaining permanently (Citizenship and Immigration Canada, 2005). As the foreign-born population continues to grow and change in composition, becoming an increasingly important segment of the Canadian population, the health of Canada's immigrants is an important determinant of the overall health of the population. Therefore, the migration of large numbers of people has implications for not only the health of the migrants, but also the Canadian population's health and the health care system (e.g., resources, health practitioners, cost and adequacy of services), both at the present time and in the future (Gushulak et al., 2011).

One approach to examine the health of immigrants is to look at health at a neighbourhood level and explore the health consequences of living in neighborhoods with higher proportions of immigrants. Neighbourhoods play an important role in the settlement of newly arrived immigrants. Immigrants are likely to live in neighborhoods with other migrants and members of their ethnic group upon arrival to their receiving country (Logan, Zhang, & Alba, 2002; Iceland & Scopilliti, 2008). Highly concentrated areas of immigrant settlement are thought to arise and persist because they fulfill needs of providing a familiar culture and social ties, as well as practical needs of offering more affordable housing, employment connections and language similarities (Logan et al., 2002). These are functions of what has been termed, *"immigrant enclaves"*, or neighborhoods with high proportions of immigrants or distinct ethnic composition, which may act to facilitate the process of successful adaptation among immigrants.

1.4 Purpose

Although a large body of work has accumulated on the overall health of immigrants, less is known about cancer risk, particularly cancer incidence, for immigrants in BC. The current study investigates the health of immigrants[2] in BC by examining how the regional percentage of immigrants predicts cancer incidence rates in BC. The incidence rates of all-cancers overall are examined, as well as those for specific types of cancers, including the four most common cancers in BC (i.e., lung, breast, colorectal and prostate) and less common cancers that show evidence of higher rates among certain immigrant groups or those of particular ethnic origins (e.g., liver, stomach, cervical, thyroid, pharyngeal and nasopharyngeal cancers).

The overall purpose of this study is to understand how cancer incidence rates vary by regional concentration of immigrants in BC. This study is one of the first to examine the relationship between cancer and regional concentration of immigrants in BC, while also considering other factors such as the proportion of immigrants of different ages at the time of immigration, the proportion of immigrants who immigrated during different periods of time, and the proportion of immigrants from different countries of origin. The information gained through this study will be important for focusing cancer prevention efforts in high-risk areas and potentially vulnerable subgroups in BC, as well as for public health planning by various regions and health authorities.

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[2] An immigrant is a person who was born in another country and was not a Canadian citizen at time of birth. In the present study, the immigrant population does not include non-permanent residents or refugees.

1.5 Study Goal and Objectives

The overall goal of this study is to understand how regional immigrant density is associated with regional cancer incidence rates in BC. Other additional factors that may be associated with cancer incidence rates will also be explored, such as immigrant duration of residence, age at immigration, and country of origin. The specific research objectives of the study are to:

i. Understand how cancer incidence rates are associated with the proportion of immigrants in a region
ii. Understand how cancer incidence rates are associated with the proportion of recent and established immigrants in a region
iii. Understand how cancer incidence rates are associated with the proportion of immigrants in a region from specific age groups at the time of immigration
iv. Understand how cancer incidence rates are associated with the proportion of immigrants in a region from a specific country of origin (i.e., Asian, European, or developed countries)

1.6 Thesis Overview

This thesis is composed of five chapters. The first chapter highlights the importance of examining cancer risk among immigrant populations and introduces the study purpose and research objectives. Chapter 2 provides a review of the empirical literature and the conceptual framework that provided context and informed the objectives of this study. The literature review begins with an overview of the immigrant population in Canada and British Columbia, highlighting the changing trends in Canadian immigration and the overall health status of immigrants. Cancer incidence and mortality among immigrants is discussed and the literature is synthesized by influential factors such as the ethnic origin of immigrants, age at the time of immigration, and years since migration. The final section of the review presents the conceptual model and discusses the key correlates associated with immigrant health and cancer risk, including sociodemographic, cultural and lifestyle influences, and factors relating to the process of immigration. Chapter 3 describes the study methodology, followed by the results in Chapter 4. Chapter 5 discusses the findings of the study in light of other evidence. Strengths and limitations of the study are also highlighted, along with recommendations and implications of this work for cancer control strategies and policy, next steps for research, and final remarks.

Chapter 2: Literature Review

2.1 Immigration in Canada and BC

The immigrant population is defined as people who have ever held the title 'landed immigrant' in Canada. These are people who are foreign-born (born outside of Canada) and not a Canadian citizen at the time of birth, but have been permitted to live in the country permanently. In Canada, the Immigration and Refugee Protection Act categorizes immigrants as family class, economic, or refugees (Citizenship and Immigration Canada, 2013). Family class comprises foreign-born nationals who are sponsored by family members or close relatives in Canada, including spouses and partners, dependent children, parents and grandparents. Economic immigrants include skilled workers, business immigrants, provincial and territorial nominees, and live-in caregivers who were specifically selected for their labour market skills, monetary investment, and ability to contribute to Canada's economy. Refugees are individuals who have been forced to leave their country for reasons of escaping war, persecution or natural disaster and include those who are government-assisted or privately sponsored, refugees landed in Canada, and dependents of refugees. Permanent resident status may also be granted under exceptional circumstances, such as humanitarian and compassionate consideration.

In 2006, Canada accepted a total of 251,640 permanent immigrants. Economic immigrants comprised the largest category accounting for 55% (138,248) of immigrants accepted, followed by family class immigrants at 28% (70,516) and refugees and other permanent immigrants comprising the remaining 17% (42,876) (Citizenship and Immigration Canada, 2013). The current study does not include refugee claimants and non-permanent residents (i.e., temporary residents comprised of foreign students, workers, businessmen or visitors who have been authorized to be in the country for employment or student purposes).

Although all BC residents are eligible for universal access to health care and health coverage under the Canada Health Act through BC's Medical Service Plan (MSP), the public health insurance system in the province, coverage is subject to a minimum three-month waiting period following application. During the waiting period, new immigrants to Canada may require temporary health insurance through the private sector or specialized programs such as the Interim Federal Health Program (Newbold, 2009). Not only are these temporary alternatives costly, but immigrants may also experience other challenges in maintaining their health or accessing healthcare services due to challenges with language proficiency (Pottie et al., 2008; Anderson et al., 2003; Canadian Partnership Against Cancer, 2014) and differences in cultural beliefs, knowledge, or gender roles (Hislop et al., 2003; Johnson et al., 1999).

Immigration continues to be an important component in shaping Canadian demography, identity and population growth. According to the 2006 census, 1 in 5 people, representing 19.8% of the current population, were born outside of Canada. Compared to other major immigrant-receiving Western countries in the world, Canada's foreign-born population is only second to Australia (22.2%) and greater than the United States of America (12.5%). In 2006, 1,110,000 recent immigrants to Canada (arriving within the last 5 years) accounted for approximately 17.9% of the total foreign-born population and 3.6% of Canada's total population (Statistics Canada, 2007). Canada's immigrant population grew four times more than the Canadian-born population (13.6% and 3.3% respectively) between 2001 and 2006 (Statistics Canada, 2007). This disproportionate population growth has been attributed to the steady annual influx of immigrants admitted to the country and slower natural population growth due to relatively low fertility rates.

In recent decades, patterns of immigration have changed considerably, which has implications for understanding the health status and cancer risk among immigrant populations. Fundamental changes that occurred in Canada's immigration policy in 1967 and the mid 1980s impacted the background of new immigrants in terms of their country of origin, as well as the quantity of immigrants applying for permanent residency in Canada. There was no longer a preference for immigrants from European countries and the overall number of immigrants admitted annually to the country increased (Citizenship and Immigration Canada, 2005). As a result of these policy changes, the number of Asian born immigrants (including the Middle East) arriving to Canada since the late 1970s have steadily increased, which has implications on the health status of immigrants, as cancer risk tends to vary according to region and origin (World Health Organization, 2008). Nearly 6 in 10 (58.3%) of the more than 1.1 million immigrants who arrived to Canada between 2001 and 2006 were born in Asian countries (Statistics Canada, 2007). In 2012, the top five countries of origin for immigrants to Canada were: China (33,018), Philippines (32,747), India (28,943), Pakistan (9,931) and the United States (9,414). Since 2004, the Philippines, India and China have been the top three source countries of immigrants arriving to Canada (Citizenship and Immigration Canada, 2013). In contrast, before 1986, the United Kingdom and Italy used to be the primary source county of immigrants who landed in Canada. In the 1950s, the top 10 source countries of immigrants to Canada were European, yet by 1997, only two of the top 10 source countries were European (Kessel, 1998). Furthermore, at the time of the 1971 Census, the majority of the foreign born population were born in Europe, accounting for 61.6% of new immigrants; by 2006, only 16.1% of recent immigrants originated from Europe (Statistics Canada, 2007). Among immigrants living in BC at the time of the 2006 census, a greater number of European born immigrants (81.2%) came to Canada in 1991 or earlier, whereas a greater number of Asian born immigrants (63.4%) arrived after 1991 (Ip, 2008). Figure 1 illustrates the changing distribution of recent immigrants to Canada by regions of birth across census years.

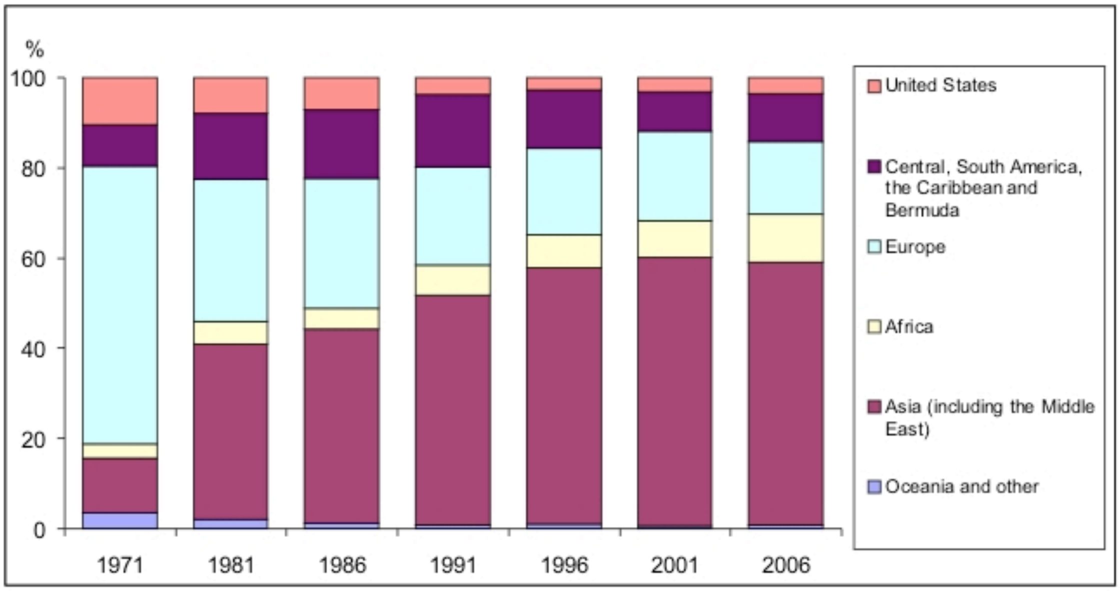


Figure 1. Region of birth of recent immigrants to Canada, 1971 to 2006

Source: Statistics Canada, censuses of population, 1971 to 2006.

Most immigrants in Canada (66.9%) report speaking one or both of Canada's official languages, English and French (Citizenship and Immigration Canada, 2013). Recent immigrants are relatively young and tend to be younger compared with the total immigrant population in Canada. In 2006, 56.7% of people who came to Canada in the last five years were between 25 and 54 years old, compared with 48.7% of total immigrants. Children under 15 years old accounted for 17.9% of the recent immigrant population, and another 16% were between the ages of 15 and 24. In contrast, only 4.7% and 8.9% of total immigrants were under 15 years old and aged 15 to 24 respectively. Mid-age adults aged 55-64 and seniors aged 65 and older only account for a relatively small proportion of recent immigrants at 5.4% and 4% respectively, yet these age groups represent a larger proportion of the total immigrant population at 16.7% and 21% respectively.

BC has the second highest proportion (27.5%) of foreign-born people in Canada, with recent immigrants accounting for approximately 4.36% of BC's population (Ip, 2008). In 2012, the source areas of immigrants to BC were as follows: Asia and Pacific (68.7%), Europe and the United Kingdom (12%), Africa and the Middle East (9.6%), South and Central America (4.9%), and the United States (4.8%) (Citizenship and Immigration Canada, 2013). The ethnic and cultural structure in BC, particularly in the census metropolitan area of Vancouver where the majority of the population is located, is highly diverse and varies widely by region. For example, in the Local Health Area of Richmond, 57.4% of the population are immigrants and Chinese is the most predominant ethnic group (45%), whereas in Surrey, immigrants represent 38% of the area's population and East Indian is the most predominant ethnic group (24%). In contrast, immigrants represent only 17% of the population in Langley and English is the most commonly reported ethnic group (37%).

2.2 Immigrant Health and the "*Healthy Immigrant Effect*"

2.2.1 Self-Reported Health Status

Immigrants who have recently arrived to Canada tend to have superior health compared to the native-born population, a phenomenon known as the "*healthy immigrant effect*" (McDonald & Kennedy, 2004; McDermott et al., 2011; Ng, Wilkins, Gendron, & Berthelot, 2005; Gee, 2003; Perez, 2002a; Chen, Ng, & Wilkins, 1996a; Chen, Wilkins, & Ng, 1996b). Despite the majority of immigrants arriving from developing countries where indicators of mortality and morbidity tend to be worse, this disparity in health is observed between immigrants and native-born populations upon arrival in the new country. Much of the research on the health status of immigrants has focused on general self-reported health. For example, a number of studies document that 97% of immigrants report their health as 'good, very good, or excellent' approximately six months after arriving to Canada, compared with 88% of the Canadian-born population (McDonald & Kennedy, 2004; Ng et al., 2005; Perez, 2002a; Chui, 2003). However, the healthy immigrant effect is not universally-reported and appears to be sensitive to how health is defined and measured. Evidence for self-assessed health status is mixed or not as strong as the evidence for other indicators of health and the presence of chronic conditions (e.g., McDonald & Kennedy, 2004; Dunn & Dyck, 2000; Newbold, 2005a; So & Quan, 2012; Hyman, 2007; Laroche, 2000). For instance, Newbold (2005a) found mixed support for the healthy immigrant effect, as immigrants were not more or less likely to rank their health as fair or poor compared with the native-born population, yet the native-born were at lower risk to transition to poor health over time. Other Canadian literature has also documented inconsistent patterns between immigrant characteristics and health outcomes (Dunn & Dyck, 2000), or no significant differences between the health status of immigrants and the Canadian-born population (Laroche, 2000).

2.2.2 Chronic Diseases – Cancer Incidence and Mortality

This healthy immigrant effect is evident not only regarding general self-reported health among foreign-born populations, but a similar pattern is seen for a number of other health outcomes such as disability, mental health, body mass index (BMI)/obesity, birth outcomes, all-cause mortality, and chronic conditions, both in general and specific conditions such as cancer, diabetes, cardiovascular disease and high blood pressure. Overall, the evidence is quite robust for the presence of the healthy immigrant effect for the incidence of many chronic diseases for both men and women in Canada (Ng et al., 2005; Ng, 2011; Newbold & Danforth, 2003; Pérez, 2002; Chen et al., 1996a; Chen et al., 1996b; Chui, 2003; Ali, 2002; McDonald & Kennedy, 2004). Immigrants report fewer chronic conditions (including cancer) than the Canadian-born population and are less likely to have any long-term disability (McDonald & Kennedy, 2004; Pérez, 2002; Chen et al., 1996a), while simultaneously benefiting from more disability-free years, lower age-adjusted all-cause mortality rates, and longer life expectancies than Canadian-born residents (DesMeules, et al., 2005; Trovato, 2003; Ng, 2011; Chen et al., 1996b; Omaribaa, Ng & Vissandjée, 2014).

Compared to native-born Canadians, immigrants in Canada tend to have a lower risk of overall cancer incidence (Carriere, Sanmartin, Bryant, & Lockwood, 2013; McDermott et al., 2011;

McDonald & Kennedy, 2004; Yavari et al., 2006; Hislop et al., 2007) and cancer mortality (Gushulak et al., 2011; DesMeules et al., 2005; Ng, 2011; Omaribaa et al., 2014; Balzi et al., 1995). Reduced rates of all-site cancer among immigrants have been demonstrated across a number of national Canadian studies and reviews of the literature (e.g., Hyman, 2007; McDermott et al., 2011; Sheth et al., 1999). However, the risk of cancer differs by cancer type. Research from both provincial (Luo et al., 2004) and national (Kliewer & Smith, 1995a; Kliewer & Smith, 1995b) studies of breast, ovarian and prostate cancer support the general conclusion that cancer incidence and mortality are lower among immigrant women and men compared to the host population. Similarly, reduced rates of colorectal (Virk et al., 2010; Yavari et al., 2006) and breast cancer (Yavari et al., 2006) have been observed among immigrants to BC compared to the general BC population.

In an ecological-based study examining age-standardized incidence rates of cancer across terciles of the concentration of foreign-born populations in Canada, Carriere and colleagues (2013) observed evidence of lower overall cancer risk among areas of highly concentrated foreign-born populations for cancers of all-sites and common cancers of the lung, breast, colorectal and prostate. For all-cancers, areas with a high concentration of foreign-born had a cancer incidence rate of 388 per 100,000 individuals, whereas areas with a low concentration of foreign-born had an incidence rate of 493 per 100,000 individuals (IRR: 0.79, 95% CI: 0.78-0.79). However, for cancers of the liver, nasopharynx, and thyroid, higher rates of cancer were found among highly concentrated foreign-born populations. The authors suggest the findings may be due to the fact that areas with a high concentration of foreign-born populations had higher amounts of Asian-born individuals who may carry a reduced risk for overall cancers and a higher risk for particular cancers of the liver, nasopharynx, and thyroid.

Other research also supports this contrary pattern of cancer risk among immigrants for cancers of the liver, stomach, pharynx and nasopharynx. Chen, Yi and Mao (2008) examined the geographical variation in liver cancer in Ontario and concluded that the proportion of immigrants was a significant predictor of age-standardized incidence ratios. National research in Canada also shows a greater risk of incidence and death for cancer of the liver for both males and females (Jiang et al., 2011; McDermott et al., 2011; DesMeules et al., 2005). Higher mortality rates have been found for stomach cancer among male and female immigrants (Trovato, 2003; Balzi et al., 1995). Furthermore, there is a greater risk of incidence and death (for males) for nasopharyngeal cancer (McDermott et al., 2011; DesMeules et al., 2005), as well as higher incidence of oral cavity cancer and oropharyngeal cancer, especially among men (Auluck et al., 2010).

Not only does risk among immigrant populations vary by the type of cancer, but it is also influenced by immigrants' country of origin, age at the time of the immigration process, and years since immigration (e.g., Balzi, Geddes, Brancker, & Parkin, 1995; DesMeules et al., 2005; Gushulak et al., 2011). The following two sections will discuss the trends in cancer incidence and mortality among immigrants in light of these factors.

2.2.2.1 Cancer Risk by Ethnicity and Country of Origin

Health status is not equivalent across all groups of immigrants and the health characteristics of some migrant populations vary according to their country of origin and experiences in the host country (Gushulak et al., 2011). Overall cancer incidence is lower among immigrants compared to the general Canadian population across all geographic regions or countries of origin (McDermott et al., 2011). In Canada, immigrants originating from Asian countries of origin (including the Middle East), carry a reduced risk of many cancers common in Western societies, including colorectal cancer (Virk et al., 2010; Yavari et al., 2006), Hodgkin's lymphoma (Au et al., 2004), breast and prostate cancer (Luo et al., 2004; Yavari et al., 2006). For example, the incidence of Hodgkin's lymphoma is lower among Chinese immigrants in BC compared to Canadian-born residents; however, the incidence was three times higher in Chinese immigrants in BC than in residents of Hong Kong/China (Au et al., 2004). Virk and colleagues (2010) also noted a substantially lower rate of colorectal cancer among Chinese Canadians compared to the Caucasian Canadian population in BC (RR: 0.52), and an even lower rate among South Asian Canadians (RR: 0.14). In another provincially-based study in Alberta, lower age-standardized incidence rates (ASIRs) were seen for breast and prostate cancers among Chinese immigrants compared to the Canadian-born population, and higher ASIRs were observed for cancers of the liver, nasopharynx and esophagus for Chinese immigrants compared to the Canadian-born (Luo et al., 2004). These findings are consistent with national evidence indicating a higher risk among immigrants for cancers of the liver and nasopharynx, particularly for immigrants of Asian origins (McDermott et al., 2011; Carriere et al., 2013).

Despite reduced cancer risk overall, evidence suggests that nationally, there is a greater risk of developing cancers of the liver (especially among Southeast and Northeast Asian immigrants), cervix (particularly among South Asian women), nasopharynx (particularly among Northeast Asian immigrants), and thyroid among immigrant populations from Asian countries of origin (McDermott et al., 2011; Carriere et al., 2013; Hislop, Mumick, & Yelland, 1995). Incidence of oropharyngeal cancer is also higher among Chinese men, and oral cavity cancer among South Asian men and Chinese women in BC (Auluck et al., 2010). Furthermore, there is a greater risk of death for stomach cancer among non-European immigrants (Trovato, 2003), liver cancer for males and females (particularly for immigrants from Northeast Asia) and nasopharyngeal cancer for males, despite lower all-cause mortality (DesMeules et al., 2005).

For cancers that are considered "high-risk" among Asian immigrants' countries of origin, including liver, nasopharyngeal, thyroid, cervical (McDermott et al., 2011; Carriere et al., 2013), esophagus and stomach cancers (Trovato, 2003; Luo et al., 2004), the risk seems to remain for Chinese immigrants after migration, as is evidenced by the higher incidence compared with the Canadian-born host population. The risk of developing other cancers that are typically "lower-risk" cancers in Asian countries (e.g., breast, prostate) simultaneously increases over time, as the ASIRs of these cancers are higher among Chinese immigrants than Chinese residents in Hong Kong (Luo et al., 2004). A similar pattern is evident for ovarian cancer mortality rates, where the risk of mortality increases and converges to rates in the native-born population for immigrants from originally low-risk countries (Kliewer & Smith, 1995a). This trend of cancer rates becoming higher and more similar to rates in the host population than those in the originating country has also been found among South Asian Indian immigrants (Hislop et al., 2007) and West Central Asian Iranian immigrants (Yavari et al., 2006) to BC. Among Iranian immigrants to BC, rates of breast cancer were four times higher and rates of colorectal cancer were twice as high in females compared to Iranian cancer rates. Rates of prostate cancer were also higher for male Iranian immigrants compared to Iranian cancer rates. For both sexes, a striking decrease in rates of stomach and esophageal cancers was seen among immigrants compared to Iranian rates (Yavari et al., 2006).

In contrast, a generational study of Italian immigrants showed mortality risk remained significantly lower among immigrants than the Canadian host population for cancers considered low-risk among Italians (e.g., lung, colon, and breast); however, the Italian immigrants' risk of high-risk cancers (e.g., stomach, thyroid in females) remained higher compared to the host population (Balzi et al., 1995). Interestingly, cancer risk among Italian immigrant offspring who were born in Canada was similar to cancer risk in the host country for these cancers, but for many other types of cancers, offspring risk was between the immigrant population born in Italy and the Canadian host population. It is important to note, age of immigrants at the time of migration is an influential determinant of later cancer risk. That is, when Italians immigrated at a younger age, their risk of cancer was more similar to that of the host population.

Despite a higher risk for several cancer types that appears to be linked to higher cancer risk in the originating country, the overall risk of cancer incidence and death among immigrants tends to change and become more similar to the risk of the host-country population (McDermott et al., 2011; Yavari et al., 2006; Hislop et al., 2007; DesMeules et al., 2005; Kliewer & Smith, 1995a; Kliewer & Smith, 1995b; Luo et al., 2004).

2.2.3 Changes in Immigrant Health Over Time with Increasing Years Since Migration

The initial health advantage of immigrants diminishes over time and generally converges to native-born levels of health within a relatively short period of time after arrival to the host country (McDonald & Kennedy, 2004; Biddle, Kennedy, & McDonald, 2007). This decline in health can occur within as little as two to four years in some studies (e.g., Newbold, 2009; Setia et al, 2011; Kim et al., 2013), or five to ten years in others (e.g., Newbold, 2005b). For example, using data from the Longitudinal Survey of Immigrants to Canada, Fuller-Thomson, Noack and George (2011) found within four years of arrival to Canada, 15.4% of recent immigrants experienced a two-step decline in self-reported health (e.g., from 'excellent' to 'good' or from 'very good' to 'fair'), whereas only 5.7% of non-immigrant Canadians experienced a similar decline. In one study, immigrants (except for the most recent immigrants) experienced poorer health than native-born Canadians, indicating that their health did not just converge but became worse than the host population (Newbold & Danforth, 2003).

The risk of cancer incidence and mortality is also associated with the time that has elapsed since immigration to Canada. Not only are incidence and death rates lower for immigrants compared to the Canadian-born population, but this superior health of immigrants is particularly true for recent immigrants who have arrived to Canada within the last 10 years approximately. There is a gradient in the general health and overall cancer risk for immigrants – the health of immigrants becomes progressively worse over time as the length of time residing in Canada increases (e.g., Gushulak et al., 2011; Ng, 2011; DesMeules et al., 2005; Trovato, 2003). Recent immigrants experience less chronic conditions, including cancer, compared to long-term immigrants, and the odds of reporting a chronic condition increases with length of residence in Canada (McDonald & Kennedy, 2004; Pérez, 2002).

Standardized mortality ratios (SMRs) among immigrants tend to increase with more time spent in Canada (Ng, 2011; DesMeules et al., 2005) converging toward the Canadian host population rates (Kliewer & Smith, 1995a; Kliewer & Smith, 1995b). In national migration studies in Canada and Australia of both breast and ovarian cancers, SMRs of immigrants increased as the length of stay in the destination country increased, with SMRs tending to converge toward native-born rates after 30 or more years (Kliewer & Smith, 1995a; Kliewer & Smith, 1995b). Cross-sectional data comparing the health of recent and more established cohorts of immigrants also shows a trend of worse immigrant health associated with years since migration, with differences emerging after 20-25 years since migration (McDonald & Kennedy, 2004). A similar duration effect of declining health with increasing length of residence in Canada is further supported by cohort studies of all-cause and cancer-specific morality among immigrants (Ng, 2011; DesMeules et al., 2005), although even after more than 20 years in Canada, there is some evidence that immigrants continue to have lower mortality rates (Ng, 2011).

The pattern of converging rates in cancer is not always consistent. For instance, Kliewer and Smith (1995a) observed changes in breast cancer mortality rates that approximated those in the host country among 50% of the immigrant population in Australia, but only 38% of immigrants in Canada. In other work examining changes in ovarian cancer incidence and mortality over time, the authors attribute differences in cancer convergence patterns to the cancer rates in the originating country, such that convergence is less evident among immigrants coming from countries where the cancer risk is already high (Kliewer & Smith, 1995b). In another national cohort study comparing SMRs over a 15-year period, Sheth and colleagues (1999) found that although cancer rates were lower among Chinese and South Asian immigrants compared with the native-born Canadian population, cancer mortality was stable or decreased over time for immigrant groups (Sheth et al., 1999). Similarly, a longitudinal study examining change in health status over time across several indicators of health (including cancer) using the National Population Health Survey found a mixed pattern of results where immigrants were more likely than native-born Canadians to report both a decline and improvement in health over time (So & Quan, 2012). The authors suggest the mixed results may depend on the particular survey cycle or the possibility that some immigrants experience declines in health while others improve, which is both plausible and realistic given that the immigrant population is a very heterogeneous group and cancer risk may be influenced by many competing factors.

Overall, the healthy immigrant effect is most apparent among recent immigrants and those from non-European countries (e.g., Chen et al., 1996a; 1996b; Trovato, 2003), particularly Asia (Ali, 2002; Luo et al., 2004, DesMeules et al., 2005), who constitute the majority of recent immigrants to Canada. The initial health advantage of recent immigrants and subsequent decline in health status with increased length of residence in the host country is not unique to Canada. The same pattern has been observed among immigrants in other countries such as the United States (Frisbie et al., 2001; Stephen et al., 1994) and Australia (Biddle et al., 2007; Donovan et al., 1992).

2.2.4 Explanations for the Healthy Immigrant Effect

There are a number of possible competing explanations for this health advantage among immigrants, but it is generally thought to be attributed to a number of health and social factors (for a more detailed discussion, see section 2.3). First, the strict immigration admission process and medical screening upon entrance to the country means that individuals are most likely selected based on good health, education, and employability. Second, the act of migration itself involves the self-selection of younger, healthier, wealthier individuals who are more likely to migrate and withstand the physical, psychological and sociological demands of immigration. Third, there is a tendency for many immigrants to have healthier lifestyle behaviours prior to migration compared to native-born Canadians, such as lower rates of smoking, alcohol use, and improved diet (Gushulak, 2007; Osypuk, Diez Roux, Hadley, & Kandula, 2009; Perez, 2002a). Lastly, the return migration effect has also been suggested, such that if immigrants who have arrived to the new country of residence suddenly fall ill, they may return to their country of origin for reasons of comfort, familiarity, and emotional, physical and financial support (Trovato, 2003).

The subsequent decline in health with increasing time in Canada may be a consequence of environmental factors and processes of acculturation such as the adoption of unhealthy lifestyle behaviours of native-born Canadians, barriers to accessing preventive or medical healthcare services, including obtaining provincial health care coverage and finding a family physician (Khadilkar & Chen, 2013; Shields & Wilkins, 2009; Wilkins & Shields, 2009), lack of language proficiency (Pottie et al., 2008; Anderson et al., 2003; Canadian Partnership Against Cancer, 2014), socioeconomic factors, and experiences of discrimination and inequality (Kim et al., 2010; De Maio & Kemp, 2010; Fuller-Thomson et al., 2011). In some immigrant populations, health conditions, as well as access to and utilization of healthcare services (e.g., screening or the detection of existing health problems), differ from the general patterns in Canadian-born populations (Gushulak et al., 2011). Use of preventative healthcare services such as breast, cervical and colorectal cancer screening may be lower among immigrants compared to non-immigrants in Canada, potentially impacting cancer outcomes due to delays in cancer detection (Khadilkar & Chen, 2013; Shields & Wilkins, 2009; Wilkins & Shields, 2009; Lofters, Glazier, Agha, Creatore, & Moineddin, 2007; Canadian Partnership Against Cancer, 2014). These disparities between immigrant and Canadian-born populations have implications for the provision of accessible health and cancer prevention services.

2.3 Correlates of Immigrant Cancer Risk

Examining the health and cancer risk of any population or subgroup is a complex task. In seeking to understand the specific risk of cancer among immigrant populations, a number of personal, social, and system-level factors must be taken into consideration. Personal or host characteristics are factors inherent in the individual that are known to influence cancer risk, such as age, sex, ethnic origin and genetic risk or predisposition. Socioeconomic and sociodemographic factors are also correlated with cancer, such as income, education, and marital status, as well as cultural norms and values. Furthermore, the process of immigration adds an additional layer of factors to consider when examining one's cancer risk in terms of the risk factors accumulated in the country of origin, exposures and risks that are acquired during the event of migration itself, and new risk factors experienced in the country of destination. A conceptual framework was adapted from the work of Trovato (2003), who originally presented a theoretical framework for considering the factors important in explaining variations in immigrant death rates. The current conceptual framework incorporates the multiple influences on immigrant health that fall under four major categories: host characteristics, country of origin effects occurring prior to immigration, selectivity effects during the process of immigration, and country of destination effects present in the host country following migration.

2.3.1 Host Characteristics

Irrespective of immigrant status, basic characteristics of the host are influential on cancer risk. Host characteristics encompasses a number of demographic and sociodemographic factors, including age, sex, ethnicity/visible minority status, marital status, income and education. Age is strongly associated with cancer, with most new cases of cancer (89%) and nearly all deaths from cancer (96%) occurring in Canadians over the age of 50 years (Canadian Cancer Society, 2015). Typically more men than women are afflicted with cancer worldwide and historically in Canada.

Worldwide, the age standardized incidence rate of cancer is nearly 25% higher in men (Cook et al., 2009, WHO, 2012). However in Canada, recent trends suggest cancer incidence and mortality rates are higher among women until the age of 59 (but not before the age of 20 when incidence rates remain higher among males) and 55 respectively, when incidence and mortality rates for males surpass rates for females (Canadian Cancer Society, 2015).

Marital status is associated with various health outcomes and quality of life. For example, both international comparisons and research in the United States consistently indicates that people who are married report better health and have lower overall mortality rates compared to people who are not married (Hu & Goldman, 1990; Wyke & Ford, 1992). This may be relevant when examining the health and cancer risk of immigrants considering elements of family structure differ between the foreign-born native-born populations in BC. Immigrants are more likely than native-born Canadians to be married (64.2% and 44.8% respectively) and less likely to be single (never married), separated or divorced (Panzenboeck, 2009).

Socioeconomic factors such as income and education are strong predictors of population health, including cancer. In many developed countries, a gradient between socioeconomic status (SES) and cancer incidence exist, whereby people with higher income, education, and occupational class tend to have a lower risk of developing many types of cancers (e.g., Faggiano, Partanen, Kogevinas, & Boffetta, 1997; Mackillop, Zhang-Salomons, Boyd, & Groome, 2000). Furthermore, people of lower SES are often worse off in terms of cancer survival, demonstrating higher rates of mortality (e.g., Schrijvers & Mackenbach, 1994). Overall, research suggests income is a strong predictor of SES and is influential on access to cancer care in Canada (Maddison, Asada, & Urquhart, 2011).

There are also racial and ethnic disparities in cancer morbidity and mortality that cannot be fully accounted for by SES alone. People of certain ethnicities or ethnic origins have a higher risk of some types of cancer and a lower risk of others. For instance, the disparity in breast cancer mortality rates between black and non-black women in the USA has been well documented, with research consistently showing that black women die of breast cancer at a much higher rate than white women despite lower incidence rates (e.g., Moormeier, 1996; Hunt, Whitman, Hurlbert, 2013). Although differences in tumour biology and reproductive factors may partially account for lower breast cancer risk among black women in the USA, the cancer is consistently diagnosed at a later stage when tumours are more advanced in black women (Moormeier, 1996). Other research on ethnic differences in cancer indicates South Asian women may be at a higher risk for cervical cancer (Hislop, et al., 1995; Grewel, Bottorff, & Balneaves, 2004). The higher rates of cervical cancer in South Asia, particularly India, is not due to race or ethnicity per se, but rather it may be linked to other social and systems-level factors associated with living in the region, such as marriage at a young age, multiparity, multiple abortions, and lack of health services (Grewel et al., 2004). In another example, a comparison of cancer incidence rates in China and the USA revealed that cancers of the liver, stomach, esophagus and nasopharynx were more commonly seen in China than in the USA (Wang et al., 2012). Additional support in the literature indicates nasopharyngeal cancer is most common in Chinese populations in South Asia and Southeast Asian populations (American Cancer Society, 2015).

Genetic disposition of the host is also considered under characteristics of the host, as some individuals may have a genetic predisposition for certain diseases. For example, there is evidence suggesting nasopharyngeal cancer may be linked to a genetic susceptibility, along with exposure to environmental factors (American Cancer Society, 2015; DesMeules et al., 2005). Different inherited tissue types are associated with a higher risk of developing nasopharyngeal cancer, and since tissue types affect immune responses, they may influence reactions to exposure to Epstein-Barr virus. Other types of cancer, such as some forms of breast cancer for instance, have a genetic and heritable component to the disease. Demographic factors, socioeconomic status, and genetic susceptibility discussed here are all predisposing factors that have the potential to increase the risk of cancer incidence among hosts or subgroups of the population.

2.3.2 Country of Origin Effects

A number of factors occurring within immigrants' country of origin may contribute to cancer risk. As previously discussed, birthplace country itself, such as European versus Asian countries or more or less developed countries, correlates to cancer risk. For instance, immigrants who migrate from underdeveloped countries may be more likely to report poor health (Setia et al., 2011). It is challenging to determine which factors influencing cancer related to ones' place of birth are due to the ethnic origins of individuals, and which are exposures associated with being born and raised in that particular country or region of the world. Cancer risks may be attributable to various lifestyle behaviours, cultural norms, values and beliefs, or environmental exposures to cancer-causing agents and viral infections within ones' country of birth.

Lifestyle factors, including tobacco use, diet, obesity, levels of physical activity, and alcohol intake, are highly influential on the risk of cancer and considered modifiable risk factors (Colditz et al., 2006; Gotay, 2010; World Cancer Research Fund/American Institute for Cancer Research, 2007). For instance, it is estimated that 30% of cancer deaths are attributed to tobacco and approximately another 32% are attributed to diet (Petro & Doll, 1981; Willett, 1995). There is considerable variability in the extent to which people engage in these types of lifestyle factors between individuals and across the world. Although a decline in smoking rates has been seen in men and women in North America, rates are rising in other regions of the world such as China in Eastern Asia and parts of Europe, particularly among women (Shafey, Dolwick, & Guidon, 2003). In an international study of fruit and vegetables consumption across 52 countries, the majority (78%) of individuals did not consume the recommended five daily servings, with prevalence rates of low fruit and vegetable intake ranging from 37% (Ghana) to 99% (Pakistan) (Hall, Moore, Harper, & Lynch, 2009).

Many immigrants originate from regions of the world where lifestyle behaviours are healthier compared with the Canadian-born population, such as lower rates of smoking, alcohol use, and healthier diets that that tend to be lower in fats (Gushulak, 2007; McDonald, 2006; Osypuk et al., 2009; Perez, 2002a). Several studies have examined how the health status and health behaviours among immigrants compare with the Canadian-born population as time since immigration increases. In terms of health behaviours, immigrants smoke less than their Canadian-born counterparts (Canadian Partnership Against Cancer, 2014), particularly non-European immigrants (compared to European immigrants), recent immigrants and immigrant woman (Perez 2002a; McDonald, 2006; Chen et al., 1996a); immigrants are less likely to be overweight or obese (Canadian Partnership Against Cancer, 2014), particularly immigrant men, and recent immigrant women who arrived less than 10 years ago had lower BMIs (Perez 2002a); immigrants have lower rates of alcohol consumption and heavy drinking or dependence (Perez 2002a; McDonald, 2006; Ali, 2002; Canadian Partnership Against Cancer, 2014); however, immigrants fare worse than Canadian-born on physical activity levels (McDonald, 2006; Osypuk et al., 2009; Perez, 2002a). Evidence of fruit and vegetable consumption is mixed, with one study finding immigrants consume fruits and vegetables more frequently than Canadian-born (Perez, 2002a) and another study finding immigrants fare worse (McDonald, 2006).

Cultural norms, values and beliefs where individuals were born and raised can also be influential on health. There may be differences in the ways people view and value health, as well as differences in their knowledge of cancer and preventative practices, influencing their use of health services and engagement in preventative health practices or certain lifestyle behaviours. For instance, in one study of South Asian women in Toronto, Canada, more than half (54%) of women admitted they did not know much about cancer, and only 5% of the women thought cancer could be cured (Choudhry, Srivastava, & Fitch, 1998). These types of differences in cultural beliefs, knowledge, and views of health have been identified as potential barriers to the use of cervical cancer screening among Chinese woman in Canada (Hislop et al., 2003). In some cultures, cancer is thought to be stigmatizing and it may not be socially acceptable to discuss a cancer diagnosis or even speak the word, as doing so is believed to evoke it or accelerate the disease by causing additional symptoms (Johnson et al., 1999). For many South Asian women, misperceptions of cancer risk or holding fatalistic beliefs about cancer as a fearful, painful, and untreatable disease or "death sentence" can negatively influence their health behaviours and practices, including avoidance or under-utilization of medical and preventative health care services (Choudhry et al., 1998; Johnson et al., 1999; Bottorff et al., 1998). Furthermore, it may not be common practice or fit with some cultures' holistic views of health to seek health care services in the absence of symptoms, such as consult a physician for regular check-ups or participate in cancer screening programs (Bottorff et al., 1998; Choudhry et al., 1998; Johnson et al., 1999).

Exposure to cancer-causing agents or viruses in ones' home or work environment is associated with increased risk of developing cancer. Worldwide, approximately 15 to 20% of cancers are attributed to infectious agents, particularly viruses. In developing countries, infectious agents account for an even greater proportion of cancers (26%), especially compared with more developed countries (8%) (World Health Organization, 2008). For example, a higher risk of incidence or death of liver, stomach, cervical, and nasopharyngeal cancers among some Asian immigrant populations may reflect an early life exposure or event in the country of origin, such as exposure to the Hepatitis viruses B and C, Helicobacter pylori (H. pylori), human papillomaviruses (HPV), or Epstein-Barr virus respectively (McDermott et al., 2011; Luo et al., 2004; DesMeules et al., 2005; Trovato, 2003; Gotay, 2010). Nasopharyngeal cancer is also associated with diets high in salt and excessive exposure to other occupational or environmental agents such as dust and smoke (McDermott et al., 2011; Luo et al., 2004). There are numerous additional exposures to common cancer-causing agents in the environment, some of which include exposure to the sun and ultraviolet light, ionizing radiation, air pollution or emissions, water pollution such as arsenic, and contamination of food by environmental chemicals (Rushton, 2003; Stephen et al., 1994). The proportion of cancer deaths attributed to overall occupation and environmental pollution is estimated to be 4% and 2% respectively (Petro & Doll, 1981). There is also potential for the exposure to acute or chronic stresses in the country of origin prior to relocation. For instance, some immigrants may have experienced traumatic events such as war or violence, psychological trauma or persecution in their country before migrating to the new country of destination.

2.3.3 Selectivity Effects

Observed differences in the health and cancer risk of immigrants may be a result of selectivity effects that occur during the immigration process. Immigration itself may involve the self-selection of younger, healthier individuals who are more likely to migrate and withstand the physical, psychological and sociological demands of immigration (Gushulak, 2007). Those who are older or in poor health are less likely to migrate (Chen et al., 1996b). This may account for the reason recent immigrants tend to be younger than the general immigrant population, as those are the type of individuals who are most likely to make the move while in good health and seeking education or employment opportunities. Age at immigration is an important factor to consider because we expect the risk or cancer will become more similar to the native-born population the younger migrants are when they arrive (Balzi et al., 1995; Azerkan et al., 2008). For instance, when Italians immigrate to Canada at a younger age, their risk of cancer is more similar to that of the host population (Balzi et al., 1995). Younger children have spent less time in their country of origin and therefore less time exposed to environmental exposures and lifestyles characteristic of their hometown. At the same time, more time is spent in the new country of destination where a different set of exposures persists. Arriving in Canada at a younger age suggests that migrants are more likely to be integrated into the local sociocultural context and adopt lifestyle behaviours and beliefs similar to those of the native Canadian-born population.

Migrants arriving to Canada must complete a strict immigration admission process and medical examination upon entrance to the country where those with existing illnesses or chronic conditions are likely screened out and denied admission (Marrocco & Goslett, 1993; Gushulak, 2007). According to Canada's Immigration Act*,* medical examination includes a mental examination, a physical examination and a medical assessment of personal records (Marrocco & Goslett, 1993). The formal process of migrant screening would undoubtedly lead to the positive selection of those who meet the requirements of health, education and employability, meaning those who hold the biggest potential to contribute to society and the Canadian economy are admitted. Employability, one of the factors influencing approval to immigrate to Canada, requires a certain level of health. Immigrants are generally selected for better physical and psychological health than their counterparts in their country of origin, and therefore are likely not representative of the populations of their countries of origin. Furthermore, wealth and monetary value are also likely contributors to migration and the selection of immigrants. The migration process itself may be stressful and traumatic for some, or relatively quick and uneventful for others. These experiences and the extent to which they impact health and wellbeing are likely determined in part by affluence and resources of the migrant.

The return migration effect has also been suggested, such that if immigrants who have arrived to the new country of residence suddenly fall ill or they are struggling to adapt to the new experiences (e.g., a long period of unemployment), they may self-select to return to their country of origin for reasons of comfort and support or practicality and convenience (Trovato, 2003). Some authors refer to this as the "salmon bias" effect (Palloni & Arias, 2004). For instance, one may wish to return to a place of familiarity, to be closer to family and friends, or for emotional, physical and financial support. The return of less healthy or adaptable immigrants could potentially leave a more healthy immigrant group remaining. However, as Trovato (2003) points out, this phenomenon is less likely to occur in Canada as most immigrants who arrive stay permanently (Citizenship and Immigration Canada, 2005). Some research suggests neither the selection of healthier immigrants nor the return migration effect accounts for lower mortality rates among some immigrant groups, and that other factors must be operating beyond selection effects (Abraido-Lanza, Dohrenwend, Ng-Mak, & Turner, 1999).

2.3.4 Country of Destination Effects

Discrepancies between the health of immigrants and Canadian-born may also be influenced by a number of factors that occur within the new country of destination following migration. Over time, the health status of immigrants tends to decline with longer durations of stay in the receiving country (Ali, 2002; Chen et al., 1996a; Gee et al., 2004; Subedi & Rosenberg, 2014), or in some cases, assimilate or converge towards the native-born population over time (Azerkan et al., 2008; McDonald & Kennedy, 2004; Biddle et al., 2007). The decline in immigrant health with increasing years in Canada may be a consequence of a number of factors, including psychological or acculturative stress, experiences of discrimination and inequality, lack of language proficiency, processes of acculturation, and barriers to accessing preventive or medical healthcare services.

The migration experience and process of re-settlement is a period marked with great change and stress, undoubtedly influencing the health of the migrants over time. Psychological demands of migration include disruptions to supportive relationships with friends and family in the home country (may evoke feelings of loss, anxiety, depression), experiencing social exclusion and isolation, culture shock and loss of a familiar sociocultural system, and arriving to an unfamiliar country where basic requirements must be met to achieve sustainability, including finding living accommodations and employment (Vega, Kolody, & Valle, 1987). Successful navigation of the migration process requires adaptation as immigrants face the need to re-establish roles in the receiving country, including building relationships and social support networks, and establishing economic viability. Not only is navigating the multitude of changes a demanding task, but ones' satisfaction with the newly established roles, economic and social conditions is also important. Many migrants leave their home country with expectations and hopes of finding a better life and it is possible that unfulfilled expectations could result in psychological distress and negatively impact health (Vega et al., 1987). Conversely, migrants may hold different aspirations and definitions of "success" compared to native-born populations, and culturally valued goals of material success in the new country of destination may not exert the same stressors on the foreign-born population as the native-born population, at least initially.

Migration may be associated with a loss in socioeconomic status for some, including financial constraints and challenges securing employment as immigrants struggle to re-establish self-sufficiency in the new country. Socioeconomic inequalities such as lower income and poverty are a struggle for many immigrants and are inversely associated with physical and mental health (De Maio & Kemp, 2010; Subedi & Rosenberg, 2014; Logan et al., 2002). On average, immigrants' income is less than non-immigrants, earning 88% of what non-immigrants earn. Furthermore, immigrants are nearly twice as likely (16%) to be classified as living under low-income circumstances compared with non-immigrants in 2005 (7.5%) (Panzenboeck, 2009). The transition to poor self-reported health among visible minorities and immigrants is partly driven by inequality and experiences of discrimination or unfair treatment (De Maio & Kemp, 2010; Setia et al., 2011; Fuller-Thomson et al., 2011). Furthermore, poor language proficiency, that is, not being able to communicate in one of the official languages in Canada (English or French) is also associated with poor self-reported health among immigrants (Anderson et al., 2003; Canadian Partnership Against Cancer 2014), particularly among women (Pottie et al., 2008).

Another contributing factor to immigrants' decline in health with increasing time in Canada is acculturation. Acculturation is a multidimensional process whereby immigrants adopt the attitudes, values and behaviours of the new host population gradually over time as they are integrated into the new culture, while also retaining a degree of identification with their original ethnic culture (Phinney, 2003). The association between acculturation, health behaviours and health outcomes among immigrants and minority groups is a well-documented area in the literature (see Berry, 2005 and Myers & Rodriguez, 2003 for more recent discussions), and research generally supports the acculturation hypothesis for the convergence of immigrants' health to native-born levels (see Myers & Rodriguez, 2003 and Hyman, 2001; 2007 for an overview). Although immigrants tend to arrive with healthier lifestyle behaviours compared to the Canadian-born population, including lower rates of smoking, alcohol intake, and improved diet, behaviours change over time as immigrants adopt certain lifestyle habits (Chen et al., 1996a; Gushulak, 2007; McDonald, 2006; Osypuk et al., 2009; Perez, 2002a). For instance, some research suggests alcohol consumption and smoking increases with years in Canada for most immigrant men (after 10-20 years and more than 20 years respectively; McDonald, 2006) and possibly for immigrant woman who have lived in Canada for 30 or more years (Perez, 2002a). Chen et al. (1996a) also documented a change in smoking behaviour between recent and established immigrants, where recent non-European (75%) and European (56%) immigrants were more likely to have never smoked compared with long-term non-European (62%) and European (38%) immigrants. Furthermore, Perez (2002a) noted that immigrant men who had been in Canada for 20-29 years and immigrant women who had been in Canada for 15-29 years showed lower fruit and vegetable consumption that was similar to the Canadian-born population.

Other research has also found evidence supporting the acculturation hypothesis in Canada. New immigrants are less likely to be overweight and (for women) obese compared with Canadian-born, but as the length of time in Canada increases, the probability of being overweight increases (McDonald & Kennedy, 2005a). Similarly, Ng and colleagues used longitudinal data from the National Population Health Survey and found an overall decline in self-assessed health among non-

European immigrants over time, especially those who had recently immigrated. Increases in physical inactivity and obesity also occurred over time, and recent non-European immigrants were nearly twice as likely to experience a substantial weight gain compared with native-born Canadians. Over time, they were also more likely than Canadian-born to become frequent visitors to doctors (Ng et al., 2005). However, research examining the explanatory role of health behaviours may not fully account for the initial health gap or convergence in health between foreign- and native-born populations (Perez, 2002a; McDonald, 2006; Ng et al., 2005).

In some immigrant populations, health conditions as well as access to and utilization of healthcare services (e.g., screening and the detection of existing health problems) differ from the general patterns in Canadian-born populations (Gushulak et al., 2011). Challenges accessing preventive or medical healthcare services may be due to barriers in meeting basic needs such as obtaining provincial health care coverage and finding a family physician (Khadilkar & Chen, 2013; Shields & Wilkins, 2009; Wilkins & Shields, 2009). In some cases, it is possible that discrepant health between native and foreign-born populations is simply because health conditions are under-reported among recent immigrants due to under-utilization of health services (that would otherwise diagnose existing conditions). Over time, the apparent worsening of immigrant health may actually be improved access to and use of health services, leading to greater recognition of existing but undiagnosed conditions.

Use of preventive healthcare services such as breast and cervical cancer screening may be lower among immigrants compared to non-immigrants in Canada, potentially impacting cancer outcomes due to delays in cancer detection and treatment (Canadian Partnership Against Cancer, 2014; Khadilkar & Chen, 2013; Lofters et al., 2007; Shields & Wilkins, 2009; Wilkins & Shields, 2009). Not only do foreign-born individuals have limited information about and experience with their new health care system following migration (including knowledge and experience with preventive health practices such as screening), but there may be an overall lack of knowledge about cancer and cancer risk factors, language barriers to the use of health services, and as highlighted earlier, cultural differences that influence health practices (Gupta, Kumar, & Stewart, 2002; Hislop et al., 2003; Leclare, Jensen, & Biddlecom, 1994). Upon immigrating to a new country, a new set of values or beliefs may prevail and individuals are faced with a complex task of accommodating conflicting or multiple beliefs. However, knowledge and health beliefs are modifiable and evidence suggests information and education provided in a culturally sensitive manner is essential to address the potential barrier to health care (Johnson et al., 1999; Grewal, Bottorff, & Balneaves, 2004).

Regions highly concentrated with immigrants may provide a unique protective effect on immigrant health by potentially mitigating some of these negative experiences and facilitating successful immigrant adaptation into the new country and culture**.** Immigrants and ethnic minorities are likely to group together and live in neighborhoods that are already highly concentrated with other immigrants and people of similar ethnic origins (Logan et al., 2002; Iceland & Scopilitti, 2002). A welcoming community populated with individuals with similar ethnic backgrounds or experiences provides new immigrants with the opportunity to maintain their sense of cultural distinctiveness and unique social connections, providing access to emotional support and cultural goods, facilitating the process of integration, and promoting well-being (Pan & Carpiano, 2013). Many immigrant families live more closely together and have more traditional family networks that reside in tight-knit communities.

These integrated communities and strong social networks may also allow foreign-born individuals to have greater control on the activities of members, potentially exerting positive influences on lifestyle behaviours. Living in densely populated immigrant communities or regions (ethnic or cultural enclaves) may exert a protective effect on the health of immigrants in terms of slowing down the process of acculturation, preserving positive lifestyle behaviours, providing culturally relevant and language appropriate resources and services, and potentially shielding migrants from adverse experiences of stress and discrimination (Hochhausen, Perry, & Le, 2010; Becares, Nazroo, & Stafford, 2008; Pan & Carpiano, 2013). Regarding health behaviours specifically, a study of Hispanic and Chinese American immigrants suggests that living in a region with a higher proportion of immigrants is associated with greater availability of healthy foods and lower intake of high-fat foods, but also the potential of being less physically active (Osypuk et al., 2009). Since immigrants generally exhibit healthier diets compared with their native-born counterparts, immigrant-dense regions may start to reflect this preference as local businesses cater to demands, improving the availability of local healthy food options. As a result, all residents in that particular area may benefit as healthy diets are promoted and become easier to maintain (Osypuk et al., 2009). Pathways such as this may be among the mechanisms through which densely immigrant populated regions affect health and cancer incidence. A similar protective influence of neighbourhood immigrant concentration has been observed for a number of other outcomes, including BMI (Quan & McGrath, 2013), neighbourhood crime rates (MacDonald, Hipp, & Gill, 2012), mental health (Mair et al., 2010), and suicidal ideation (Pan & Carpiano, 2013).

2.3.5 Influences Across Factors

Further complicating the understanding of cancer risk is the notion that the relationship among these factors and cancer is likely not linear in nature, but rather a dynamic interplay among variables across time and place that may not be accurately captured in the present framework. For example, individuals' cultural norms and values established in their country of origin will influence lifestyle behaviours such as diet in both the old and new country of residence, as well as utilization of health care such as preventive cancer screening (Hislop et al., 2003; Bottorff et al., 1998). Hosts' ethnicity or visible minority status may influence later experiences of discrimination or unfair treatment and stress in the new country of destination, contributing to foreign-borns' risk of transitioning to poorer health (De Maio & Kemp, 2010; Setia et al., 2011; Fuller-Thomson et al., 2011). However, protective influences in the new country of destination such as residing in immigrant-dense regions and communities may act to offset or minimize the occurrence of the potential negative influences of discrimination or the adoption of unhealthy lifestyle behaviours, providing ethnic or culturally relevant community supports and influences for foreign-born populations (Hochhausen et al., 2010; Becares et al., 2008).

The numerous risk factors for cancer may not only interact across domains, but they are also constantly changing and evolving over time. Some host demographic factors, such as age, change naturally over time and others (e.g., education, income, marital status), are likely to change as well. Such factors exert varying levels of influence (positive and negative) on cancer risk over time. For example, cancer risks increases with age, yet greater education and income over the lifespan may be associated with lower risks for certain cancers (Faggiano et al., 1997; Mackillop et al., 2000). Beliefs, norms and values may also change over time, as may lifestyle factors such as dietary habits, physical activity levels, smoking and alcohol consumption.

Exposure to certain environmental factors or agents may also increase the risk of cancer. Not only do various risk factors accumulate across the life course and across generations to influence the development of chronic diseases such as cancer, but there may also be sensitive or critical periods where an experience, exposure or environmental influence has a greater impact on health or development. For instance, exposure to radiation or smoke at a critical period in utero or at a very young age may result in permanent and irreversible damage or disease risk. Alternatively, immigrants arriving to a new country at a young age may influence language acquisition or acculturative changes in behaviours such as diet, also potentially impacting cancer risk.

2.4 Gaps in the Literature

Although immigrants appear to have a health advantage overall, this benefit is not true for all chronic diseases or across all types of cancer. A large body of literature on the overall health of immigrants is accumulating in Canada; however, a substantial segment of the research on immigrant health has centered on general self-rated health. Furthermore, much of the research has relied on self-reports of overall health and the presence of chronic conditions rather than actual health records. Research on cancer risk and outcomes among immigrant populations has been more limited (for a review, see De Maio, 2010), with existing work focusing particularly on cite-specific cancers and cancer mortality (Kliewer & Smith, 1995a; Kliewer & Smith, 1995b; Trovato, 2003; DesMeules et al., 2005; Sheth et al., 1999; Balzi et al., 1995), and less on cancer incidence (McDermott et al., 2011; Luo et al., 2004; Au et al., 2004). To date, little work has focused on cancer incidence among immigrants in BC specifically while looking at multiple cancer types, nor included regional-level neighbourhood influences such as immigrant density, with the exception of the regional-level work completed by Carriere and colleagues (2013).

Carriere and colleagues (2013) used an ecological-based approach to investigate whether cancer incidence rates varied by the concentration of foreign-born individuals. This was a national Canadian study using a five-year span of cancer data from the Canadian Cancer Registry (2001-2006) in conjunction with the 2006 Census data. Areas were categorized by terciles of the foreign-born population at the dissemination area level (i.e., low, medium and highly concentrated areas) and age and sex-standardized cancer incidence rates were calculated using the direct method for each tercile. Results indicated lower age-standardized incidence rates of all-site cancers among areas with a high (338 per 100,000) and medium (447 per 100,000) concentration of foreign-born populations compared with areas of low concentration of foreign-born (493 per 100,000). Incidence rate ratios were then calculated to compare cancer rates of terciles 2 and 3 to that of tercile 1, the reference rate (IRR: 0.91, 95% CI: 0.90-0.91 and IRR: 0.79, 95% CI: 0.78-0.7 respectively). The same pattern of reduced cancer rates among higher concentrated foreign-born areas was evident both nationally and provincially, including BC, for lung, colorectal, prostate and female breast cancers. However, an opposite pattern was observed for cancers of the liver, nasopharynx and thyroid where higher rates of cancer incidence were found among highly concentrated foreign-born populations. For these three cancers of the liver, nasopharynx and thyroid, results were only reported at a national level and not for BC.

How the cancer risk among immigrants is distributed in BC is unclear. It is important to gain a deeper understanding of the factors that contribute to the increased risk or protection of cancer incidence rates in the growing population of immigrants in BC. Health status is not equivalent across all subgroups of immigrants and the health characteristics of some migrant populations vary according to their origin and experiences (Gushulak et al., 2011). The immigrant population in BC is diverse with respect to a number of factors, including country of origin, age at immigration, and time since immigration, and therefore, it is not surprising that various groups differ in their risk of cancer incidence. There is a need for research examining immigrant country of origin, including a more detailed breakdown of ethnic origin by sub-regions, as well as considering age at immigration and duration of residence in the host country, as these factors affect cancer risk and health outcomes of immigrants and have not been considered in similar work (i.e., Carriere et al., 2013).

Health is not simply a product of individual-level factors such as age, gender and income, but rather, contextual factors of where people live are also important (De Maio, 2010). One way to incorporate the characteristics of where people reside is to examine neighbourhood-level factors, such as regional immigrant concentration. Currently, minimal research exists to examine how regional concentration of immigrants where people live impacts health outcomes such as cancer. Evidence suggests areas with high concentration of immigrants may translate to health benefits due to the provision of cultural and social resources, potentially slowing down the acculturation process (e.g., more likely to eat healthier ethnic foods and maintain other healthier lifestyle habits from the country of origin, such as reduced smoking and alcohol consumption) and offering a safe environment where immigrants are shielded from racial discrimination (Hochhausen et al., 2010; Becares et al., 2008).

The current study contributes to the literature in two main ways. First, building off the national work by Carriere et al. (2013), new evidence examining how regional-level variables of the immigrant population predicts cancer incidence rates in BC specifically are presented using two large linked datasets. Second, the current study examines the influence of important factors on the association between immigrant density and cancer incidence that were not previously investigated by Carriere and colleagues, such as how much time has elapsed since migration, how old immigrants were at the time of immigration, and immigrants' country of birth. Additionally, the potential confounder of area-level income is adjusted for while examining the influence of immigrant density on cancer incidence. A different statistical approach to understanding these research questions will also be employed; Poisson and Negative Binomial regression analyses will be used to model cancer incidence rates while adjusting for age, sex and income, as opposed to calculating directly standardized incidence rates and comparing rates across areas.

Chapter 3: Methods

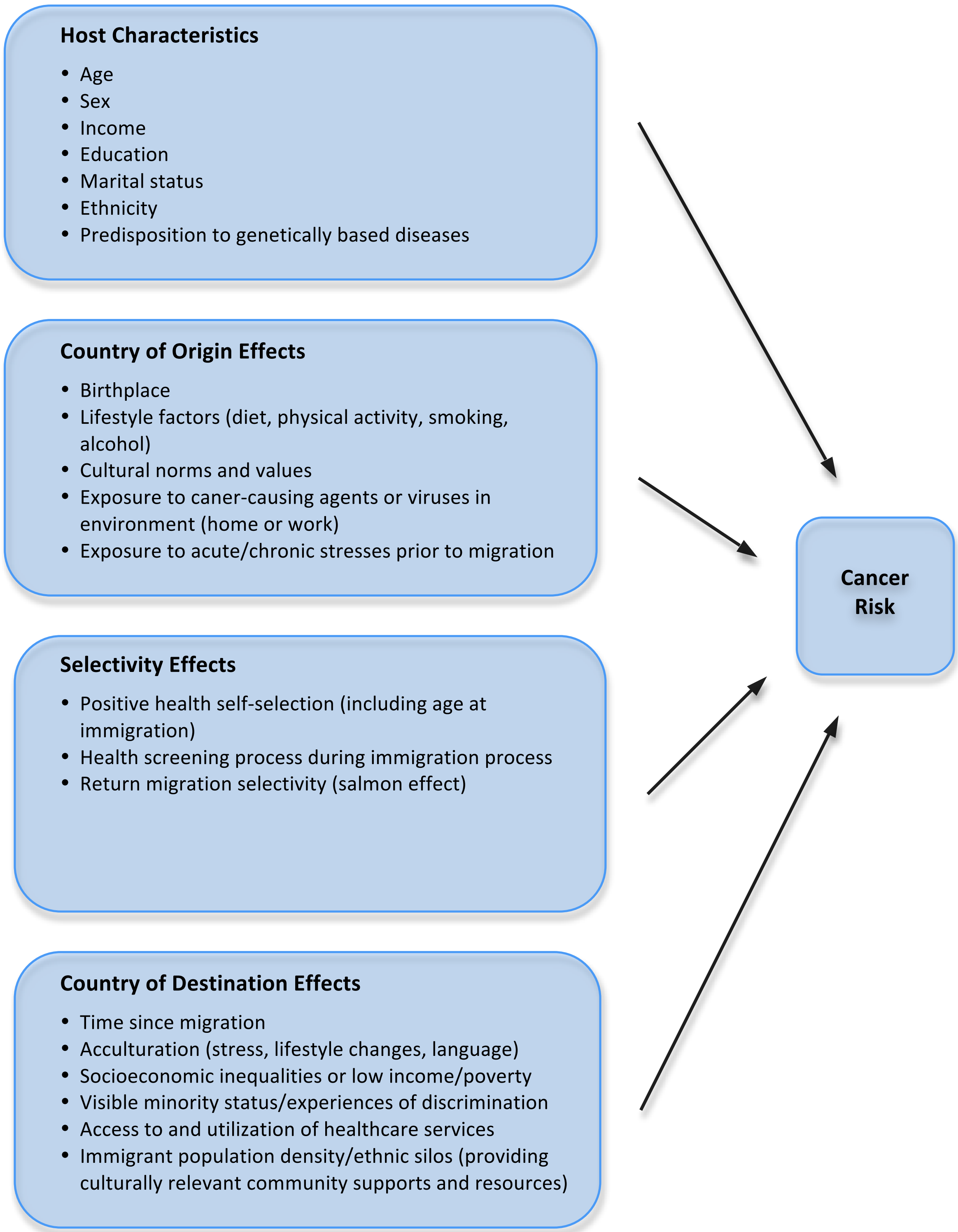
3.1 Study Design

The current study investigated how regional immigrant density predicted cancer incidence rates in BC. This was an exploratory study, and an ecological, population-based design was adopted. Ecological or spatial correlation studies examine the relationship between a risk, exposure or environmental factor and the occurrence or outcome of disease at an aggregate level, where at least one variable is measured at the group level. In these studies, the population or community is the unit of observation (Gordis, 2009).

3.2 Conceptual Framework

A conceptual model adapted from the work of Trovato (2003) incorporates multiple influences on immigrant health and was used in this study as a framework to describe the underlying sources of cancer risk in immigrant populations. Although we will not be able to examine many of the variables in this model in the current study, it provides a foundation for understanding how immigrant status may affect cancer risks. A summary of the conceptual framework used is presented in Figure 2.

Figure 2. Conceptual framework of immigrant cancer risk



Adapted from Trovato (2003)

3.3 Data

Data on all new cancers diagnosed between 2000 and 2009 in BC were obtained from the BC Cancer Registry (BCCR). Data on all cancer cases (with the exception of non-melanoma skin cancers) in the BC population are recorded in the BCCR for the purpose of monitoring the provincial burden of disease and informing cancer control efforts (BC Cancer Agency, 2014). The registry contained a total of 193,324 incident cancer cases during the 10-year period[3]. Only adults (20 years of age or older) were included in the current study, representing 191,831 cases and 99.2% of the total data file. The main variables included in the dataset were sex, age at diagnosis, year of diagnosis, tumour group and subgroup, histology and site (used to identify the cancer type), survival status, and geographic location variables. The smallest location variable available in the file was Local Health Area (LHA), which was used as the geographic region variable in the current study. Cancer data was aggregated by age, sex and LHA.

Regional-level estimates of the BC immigrant population were obtained from the Statistics Canada 2006 Census (20% sample), weighted to represent the Canadian population. Since only a sample of Canadian households are selected to receive the Census survey, Statistics Canada uses an algorithm to assign weights to the records in order to be representative of the entire population (for a more detailed description of the methodology used in the Census, see Statistics Canada, 2009). Sociodemographic and socioeconomic information are aggregated and made available at varying levels of geographic units based on census designations (e.g., census divisions, dissemination areas) and health services entities (Statistics Canada, 2008). In BC, health services are stratified into three levels consisting of 5 Health Authorities, 16 Health Service Delivery Areas (HSDA), and 89 Local Health Areas (LHA). For a list of LHAs and a map outlining LHA boundaries,

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[3] The number of new cancers documented in the BC Cancer Registry file may include multiple primary cancers diagnosed in one patient, but do not include recurrences of the same primary cancer or metastatic cases. Primary cancers are defined by the site the cancer originated, not by the metastatic site.

see Appendix A.1 and A.2 respectively. LHA was used as the geographic unit for this study because it is the lowest common level at which provincial health data (e.g., cancer statistics) are aggregated and for which BC Stats produces comprehensive statistics (e.g., immigrant and socioeconomic statistics). All census data reports were generated by LHA, allowing for direct comparison with cancer data. Furthermore, presenting results at the LHA level will be more meaningful and interpretable for provincial health services, decision-makers and health care practitioners. A regional based indicator of cancer risk allows us to understand how immigrant populations are contributing to the cancer risk in BC, in which direction the effect is, and ultimately, how these findings may impact allocation of resources and the development of programs by LHAs. Data are provided for 85 LHAs, ranging in population size from 1,925 (LHA 92–Nisga'a) to 334,430 (LHA 201–Surrey) inhabitants.

Data on the sociodemographic and ethnic profiles by LHA were obtained from the publicly available 2006 Census. The census data included variables on the immigrant population that are presented as counts by LHA for immigrant status, duration of residence, age at immigration and country of birth. Using an area-based approach, counts for each immigrant status variable were divided by corresponding LHA population estimates to compute proportions that represent the percentage of immigrants living in a LHA. The immigrant population was defined in the 2006 Census as persons who have ever held the legal designation of immigrant. The census also included additional regional-level variables for the total BC population (not specific to the immigrant population), such as language spoken, mobility status, ethnicity, visible minority status and education level, that were not the focus of the present study.

Average family household income served as a measure of socioeconomic status (SES) at the regional level. Economic statistics on average family income were generated by LHA from the BC Stats Socio-Economic Profiles using 2006 Census data. Of the 191,831 adult cancer cases in the BCCR data file, 647 cases were missing LHA identifiers and another 137 cases belonged to LHAs where income statistics could not be calculated due to small population size.[4] Thus, 784 (0.4%) of the cancer cases were excluded from analysis. The final sample used in all analyses was 191,047. Following the approach of Gotay et al. (2013), LHAs were ranked by the indicator of SES, average household income, and then divided into income quintiles (Q1-5) to each contain 20% of the total BC population. Income cut-off points are presented in Table 1 (Gotay et al., 2013).

Table 1. Categorization of income quintiles

Quintile	1 Lowest/Worst	2	3 Middle	4	5 Highest/Best
Average household income	$39,550 – $59,349	$59,350 – $63,182	$63,183 – $66,843	$66,844 – $76,311	$76,312 – $141,821

3.4 Participants

The population included in this study is that of British Columbia, specifically adult cancer cases diagnosed in BC from 2000 to 2009 (n=191,047), and the total immigrant population in BC as of 2006 (n=1,119,215). Data analysis focused on all-cancers, the four most common cancers of the breast, colon, lung and prostate, and cancers that show potential evidence of higher risk among immigrant populations or ethnic subgroups, including cervical, liver, stomach, thyroid, pharyngeal and nasopharyngeal cancers.[5]

3.5 Study Variables

A summary of the study variables is presented in Table 2.

[4] LHAs omitted from the present study with small population sizes include 51–Snow Country (n=540), 83–Central Coast (n=1455), 87–Stikine (n=995), and 94–Telegraph Creek (n=675).

[5] Within the BC Cancer Registry tumour site classification, pharyngeal cancer includes cancers within the nasopharynx, oropharynx, (including the soft palate (back of the mouth), base of the tongue, tonsils, tonsillar pillar, and vallecula), and hypopharynx (including the postcricoid region and pyriform sinus). Literature suggests immigrant populations may experience a higher incidence of nasopharyngeal cancers specifically, and therefore the current study examined incidence of cancers of the pharynx and nasopharynx separately.

Table 2. Study variables

Dependent Variable			
Cancer incidence[a] (by cancer type)	All-cancers		
	Breast		
	Cervix		
	Colon		
	Liver		
	Lung		
	Nasopharynx		
	Pharynx		
	Prostate		
	Stomach		
	Thyroid		
Independent Variables			
Sex[a]			
Age category (at time of cancer diagnosis)[a]	1: 20-24	6: 45-49	11: 70-74
	2: 25-29	7: 50-54	12: 75-79
	3: 30-34	8: 55-59	13: 80-84
	4: 35-39	9: 60-64	14: 85-89
	5: 40-44	10: 65-69	15: 90+ years
Income quintile[b]	Q1–Q5		
Immigrant status[b]			
Duration of residence[b]	Recent[6] (≤ 5 years)		
	Established (> 5 years)		
Age at immigration[b]	< 5 years old		
	5-14 years old		
	15-24 years old		
	25-44 years old		
	> 45 years old		
Country of origin[b]	European		
	– North, East, South, West		
	Asian		
	– East, Southeast, South, West Central		
	Developed[7]		

[a] Individual-level measure (aggregated by LHA); source of data: BC Cancer Registry

[b] Regional-level measure (defined by LHA) given as a proportion of the population with that characteristic; source of data: Statistics Canada 2006 Census

[6] Recent immigrants in the 2006 Canadian Census refers to immigrants who arrived in Canada between January 1, 2001 and Census Day, May 16, 2006.

[7] The 2006 Canadian Census defines developed countries as Europe, North America, Australia/New Zealand and Japan.

3.5.1 Dependent Variables

The outcome of interest is the cancer incidence rate across LHAs in BC. Incidence rate of a disease refers to the number of new cases that occur over a particular period of time in a specified population (Gordis, 2009). In this study, we are examining the occurrence of new adult cancer cases in the adult BC population during a 10-year period from 2000 to 2009. Thus, all subsequent references to cancer incidence counts and rates refer to 10-year cancer incidence counts and rates. An incident rate is a measure of disease risk as it captures a change of events or the transition from a non-diseased to diseased state (Gordis, 2009).

3.5.2 Independent Variables

All immigrant status-related variables for an individual LHA are characterized as a proportion (percentage). The primary independent variable of interest is immigrant density, as captured by the proportion of immigrants residing within each LHA. Additional continuous predicator variables include the proportion of immigrants by categories of length of time in Canada since immigration, the proportion of immigrants by categories of age at the time of immigration, and the proportion of immigrants by categories of ethnic origin.

The 2006 Census provides data on the total immigrant population by period of immigration for each LHA, and is grouped by those who arrived in Canada before 1961, 1961 to 1970, 1971 to 1980, 1981 to 1990, 1991 to 2000, and 2001 to 2006. For the purpose of this analysis, the following terms are used to define length of time in Canada since immigration: recent immigrants are those living in Canada for 5 years or less at the time of the census (i.e., arrived between 2001 to 2006) and established immigrants are those living in Canada for more than 5 years (i.e., arrived anytime prior to 2001). These two variables denote duration of residence and are categorized as a proportion of recent immigrants and a proportion of established immigrants living within each LHA population.

Age at immigration captures the proportion of immigrants in each LHA who were in one of five age categories upon arrival to Canada: less than 5 years old, 5 to 14 years old, 15 to 24 years old, 25 to 44 years old, and 45 years or older. Ethnic origin of immigrants is categorized into three main variables: the proportion of immigrants from a European country of origin, the proportion of immigrants from an Asian country of origin, and the proportion of immigrants originating from a developed country. Immigrant country of origin is further defined by sub-region. European country of origin is categorized into the four regions of Northern, Eastern, Southern and Western Europe. Asian country of origin is categorized by Eastern Asia, Southeast Asia, Southern Asia and West Central Asia (including the Middle East), and variables representing the proportion of immigrants in each of these categories were examined.

3.5.2.1 Adjusted Variables

Additional predictor variables were selected for inclusion based on evidence in the literature to suggest their associations with cancer incidence. To control for potential confounders, age, sex, and income quintile were included in all regression models as predictor variables to obtain adjusted estimates for the main effects. There is strong evidence of the association between current age and cancer, as well as sex and cancer. Cancer incidence increases dramatically as individuals become older with people 65 years of age and older accounting for more than half (56%) of all new cancer cases and nearly a third (71%) of cancer deaths (Yancik, 2005). Males are generally at a greater risk than females for most cancers; worldwide, the age standardized incidence rate of cancer is nearly 25% higher in men (Cook et al., 2009, World Health Organization, 2008). The literature also suggests an association between SES or income and cancer, such that the overall risk of many cancers is higher for individuals of lower SES (Faggiano et al., 1997; Mackillop et al., 2000). Sex, income quintile, and age group were represented as categorical variables with the reference categories being female, the lowest income quintile (Q1), and the youngest age group (20-24 years) respectively. Age was categorized into 15 categories in five-year increments, up until 90 years of age and older (e.g., 25-29, 30-34, …, 90+).

3.6 Statistical Analysis

Statistical analysis was performed in R Version 3.0, a free open source software tool for statistical computing and graphics.

3.6.1 Descriptive Analysis

The data was examined for general accuracy and outliers. The distributions of the variables were explored using counts and frequencies for categorical variables, and means, medians, ranges, standard deviations, and variance for continuous variables. Variables were also graphically represented with contingency tables (categorical variables), histograms and boxplots (continuous variables) to examine skewness, excess zeros and potential outliers. Associations between cancer incidence counts and predictor variables were examined using Pearson correlation coefficients and scatterplots. Associations among the predictor variables were also explored to consider potential sources of collinearity among the variables.

3.6.2 Analysis of Cancer Incidence Rates

Statistical analysis of cancer incidence was carried out for adult cancer cases diagnosed in BC from 2000 to 2009 for which there was complete data (n=188,949). Cancer incidence rates were calculated using counts of age and sex-specific incident cancer cases from the BC Cancer Registry (incidence rate numerator), divided by the age and sex-specific population totals from Stats Can population estimates (incidence rate denominator). Both cancer incident counts and population estimates are recorded in a stratified format by age and sex, providing the number of new cancer counts occurring in each stratum for each segment of the population at risk. Counts and population estimates are then aggregated or pooled across the 85 LHA regions. Data in stratified format allow for the use of age and sex-specific cancer incidence counts in the regression models. Models were run for both sexes, and separately by sex. The incidence rates of all cancers overall were examined, as well as specific cancers including the four most common cancers of the lung, breast, colon, and prostate, and several additional cancers that show evidence of higher prevalence among certain immigrant groups or those of particular countries of origins, including liver, stomach, cervical, pharyngeal, nasopharyngeal, and thyroid cancer.

The effect of age was adjusted for using multivariate Poisson and negative binomial regression analysis. Whether standardizing rates directly or using a Poisson regression to indirectly standardize rates, age is adjusted for when comparing regions, allowing us to remove the effects of any differences in age between the populations being compared. Using a log-linear model such as Poisson or negative binomial to obtain expected cancer counts helps to smooth rates, giving estimates of relative risk with more precision than comparing directly standardized rates (Atkinson Crowson, Pedersen, & Therneau, 2008; Frome, 1983). Furthermore, for the purposes of regional health planning and application of the study results, it may be more meaningful to use the actual observed age and sex-specific cancer incidence counts and population counts rather than applying these specific cancer rates to an hypothetical standard population where rates would not reflect the true incidence risk of a "real" population (Gordis, 2009).

3.6.3 Comparison of Poisson and Negative Binomial Regression Models for Rates

Poisson regression is useful for modeling counts, particularly those of rare events, such as the number of cancer cases in a defined population and period of time, particularly within age-strata (Lawless, 1987). An important assumption underlying the Poisson distribution is that the mean expected count within a stratum is equal to the variance of the count. However, count data are often over-dispersed, meaning the variance is larger than the mean (Nassbaum, Elsadat, &

Khago, 2008). Heterogeneity within strata, such as the variation we may expect to see within a LHA, can introduce over-dispersion. Over-dispersion indicates there is more variability in the observed counts than expected, and that the actual variance in the counts exceeds the variance in the assumptions of the model or chosen distribution (Carruthers, Lewis, McCue, & Westley, 2008). If over-dispersion is not corrected for, the estimates of the standard errors will be small, indicating we may have biased inferences and increase the occurrence of committing Type I errors, resulting in finding more significant results than truly exist, by observing smaller p-values than we should (Carruthers et al., 2008).

After fitting Poisson regression models for each cancer type, over-dispersion was examined using Pearson's chi-square (or deviance) goodness-of-fit statistics, which reflects the deviation of the observed values from the predicted values (Nassbaum et al., 2008). Under the assumption of Poisson distributed counts, the dispersion parameter should be close to one; however, the observed deviance was much greater than one for all cancers except colon and stomach, indicating severe over-dispersion. Furthermore, the Pearson's chi-square goodness-of-fit tests were statistically significant, indicating that the models do not fit the data well (i.e., the data are not Poisson distributed). With the Poisson assumptions violated, negative binomial regression was used to model the over-dispersed count data (Nassbaum et al., 2008; Ver Hoef & Boveng, 2007). Negative binomial regression can be considered an extension of Poisson regression with an additional parameter, theta, to model the over-dispersion. This model allows for over-dispersion because the variance of the counts is allowed greater than its mean, and it is considered a more robust and conservative model (Ver Hoef & Boveng, 2007). Therefore, the inferences drawn from data are more likely to be accurate (Carruthers et al., 2008).

3.6.4 Negative Binomial Regression Analysis

After examining dispersion and model fit using Pearson's goodness of fit test for Poisson and negative binomial regression models, a decision was made to use negative binomial regression to model the association between cancer incidence and the various immigrant-related predictors for all cancer types except two. For colon and stomach cancer, Poisson regression models were appropriate as the count data did not appear to be over-dispersed and model fit indicated the data were distributed as Poisson. For the remainder of the paper, the regression analysis and models will be referred to as negative binomial for simplicity.

All regression models were first run separately for each immigrant-related predictor variable. Due to the format of the census data, most immigrant-related variables were in the form of percentages and therefore, could not be combined within the same regression model. Inherent in the calculation of immigrant proportion variables is the fact that all percentages will sum to 100; thus, not only are there concerns with collinearity and overlap among predictor variables, with the same people being captured among different percent variables (e.g., the same people will be contained within a % of recent immigrants and a % of immigrants who migrated at an age of 45+ years), but it becomes problematic in statistical models to have variables summing to one or 100% in this case. After all regression models were run separately for each immigrant-related predictor variable, several additional models were run with all but one variable added to avoid the issue of all variables summing to 100%.

Negative binomial regression was used to model the association between the particular immigrant density variables of interest (independent variable) and the observed number of cancers (dependent variable), with the rate ratio as the measure of association. To control for potential confounders, age, sex, and regional income quintile were included in the models as predictor variables to obtain adjusted estimates for the main effects. By fitting the regression model, regression coefficients are obtained for each variable. The significance of individual regression estimates was measured by Wald statistics, p-values and 95% confidence intervals. The significance of overall models was assessed using the log-likelihood ratio test by comparing the likelihoods of the full model versus the null model without covariates, determining that at least one regression coefficient is different from zero. Regression estimates show a change in the log-count of cancer incidence for one-unit increase in the predictor. All estimates were scaled by 10 to represent a more meaningful change at a population level. Therefore, regression estimates show expected change in the log-count of cancer incidence for a 10-percent increase in the proportion of immigrants within LHAs. By taking the exponent or antilog of the estimated regression coefficients, we obtain the relative rate or rate ratio (RR) of cancer incidence. The RR is a measure of association or excess risk associated with a given exposure (Gordis, 2009), such as regions with a higher proportion of immigrant residents in the context of this study. If the RR is greater than one, there is evidence that the risk of cancer is higher for each 10-percent increase in the regional proportion of immigrants, whereas if the RR is less than one, the risk of cancer is lower.

The negative binomial regression analysis models the log-expected number of cancer occurrences as a linear function of our predictors (x's), using log-link function (log(E(y)) to "link" the expected response outcome (y) to a linear function and an offset term (ln(t)) to account for population at risk during the time period in each age/sex strata. The offset term is a regression variable with a constant coefficient of 1 for each observation. We have modeled the log-rate of cancer as a linear function of our predictors.

Model: $$\ln(E(y_{ij})) = \beta_o + \beta_1 x_1 + \dots + \beta_k x_k + \ln(t_{ij})$$

$$\ln(\lambda_{ij} t_{ij}) = \beta_o + \beta_1 x_1 + \dots + \beta_k x_k$$

Where y_{ij} is the cancer count in each age and sex stratum 'i' for group 'j' (LHA 1 through 85), distributed as a negative binomial random variable; t_{ij} is the population at risk in each age and sex stratum 'i' for group 'j'; λ_{ij} is the cancer rate in each age and sex stratum 'i' for group 'j' or the expected cancer incidence rate ($\lambda_{ij} = E(y_{ij})/t_{ij}$); k is the number of variables.

3.6.4.1 Analysis of the Proportion of Immigrants and Duration of Residence

Negative Binomial regression was used to model the association between percent concentration of immigrants and the observed number of cancers (Model 1). I also modeled the cancer incidence rate by percent concentration of recent immigrants (Model 2) and percent concentration of established immigrants (Model 3). Negative binomial regression models are represented by the following equation:

$$\ln(E(\text{cancer incidence count}_{ij})) = \beta_o + \beta_1(\text{immigrant \%}) + \beta_2(\text{age category 2}) + \beta_3(\text{age category 3}) + + \beta_4(\text{age category 4}) + \beta_5(\text{age category 5}) + \beta_6(\text{age category 6}) + \beta_7(\text{age category 7}) + \beta_8(\text{age category 8}) + \beta_9(\text{age category 9}) + \beta_{10}(\text{age category 10}) + \beta_{11}(\text{age category 11}) + \beta_{12}(\text{age category 12}) + \beta_{13}(\text{age category 13}) + \beta_{14}(\text{age category 14}) + \beta_{15}(\text{age category 15}) \;\; \beta_{16}(\text{male}) + \beta_{17}(\text{income quintile 2}) + \beta_{18}(\text{income quintile 3}) + \beta_{19}(\text{income quintile 4}) + \beta_{20}(\text{income quintile 5}) + \ln(\text{population}_{ij})$$

where ‘i’ represents the age and sex stratum and ‘j’ represents the LHA group 1 through 85.

An abbreviated formula will be used below and in subsequent sections to illustrate the general negative binomial regression models used for varying immigrant density variables:

$$\ln(E(y_{ij})) = \beta_o + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + \ln(t_{ij})$$

Model 1 $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{immigrant \%}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{income quintile}) + \ln(\text{population})$

Model 2 $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{recent immigrant \%}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{income quintile}) + \ln(\text{population})$

Model 3 $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{established immigrant \%}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{income quintile}) + \ln(\text{population})$

For immigrant duration of residence variables, the percentage of recent and established immigrants were calculated as a proportion of the entire LHA population, and therefore the two variables did not sum to 100% and could both be added to the same regression model predicting cancer.

Model 4 $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{recent immigrant \%}) + \beta_2(\text{established immigrant \%}) + \beta_3(\text{age}) + \beta_4(\text{sex}) + \beta_5(\text{income quintile}) + \ln(\text{population})$

3.6.4.2 Analysis of the Proportion of Immigrants by Age at Immigration

Cancer incidence rate was modeled by percent concentration of immigrants who immigrated to Canada while under five years of age (Model 5a), 5-14 years of age (Model 5b), 15-24 years of age (Model 5c), 25-44 year of age (Model 5d), and 45 years of age or older (Model 5e). Negative binomial regression models are represented by the following equations:

Model 5a $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{\% immigrants} < 5 \text{ yrs old}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{weighted income quintile}) + \ln(\text{population})$

Model 5b $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{\% immigrants 5-14 yrs old}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{weighted income quintile}) + \ln(\text{population})$

Model 5c $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{\% immigrants 15-24 yrs old}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{weighted income quintile}) + \ln(\text{population})$

Model 5d $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{\% immigrants 25-44 yrs old}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{weighted income quintile}) + \ln(\text{population})$

Model 5e $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\text{\% immigrants} > 45 \text{ yrs old}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{weighted income quintile}) + \ln(\text{population})$

After all regression models were run separately for each age at immigration variable, the proportion of immigrants from four of the five age categories (all except the proportion of immigrants aged 15-24 years old) were entered as predictors into the same regression model to examine if certain predictors were stronger.

3.6.4.3 Analysis of the Proportion of Immigrants by Country of Origin

Cancer incidence rate was modeled by percent concentration of immigrants who were born in European countries (Model 6) and Asian countries (Model 7). I further examined the proportion of immigrants from European country of origin sub-regions in four separate models (North, East, South and West Europe) and the proportion of immigrants from Asian country of origin sub-regions in four separate models (East, West Central, Southeast and South Asia). I also examined cancer rates based on originating from more-developed countries of origin (Model 8). In this case, developed countries include North America, Europe, Australia, New Zealand, and Japan. Negative binomial regression models are represented by the following equations:

Model 6 $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\%\text{ European immigrants}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{weighted income quintile}) + \ln(\text{population})$

Model 7 $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\%\text{ Asian immigrants}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{weighted income quintile}) + \ln(\text{population})$

Model 8 $\ln(\text{cancer incidence count}) = \beta_0 + \beta_1(\%\text{ immigrants from developed countries}) + \beta_2(\text{age}) + \beta_3(\text{sex}) + \beta_4(\text{weighted income quintile}) + \ln(\text{population})$

After all regression models were run separately for each country of origin variable, the proportion of immigrants for three of the four sub-regions (all except the proportion of immigrants from South Europe or South Asia for corresponding country of origin models) were entered as predictors into the same regression model to determine if the proportion of immigrants from certain regions were stronger predictors of cancer.

Chapter 4: Results

4.1 Population Description

A total of 188,949 BC adults with incident cancer cases diagnosed between 2000 and 2009 who were 20 years of age or older were included in the present study examining cancer incidence. A summary of the cancer case distribution by cancer type and sex is presented in Table 3. Compared to females, males were slightly more often diagnosed with all cancers, as well as cancers of the colon and lung. Males were approximately twice as likely as females to be diagnosed with cancers of the liver, stomach and nasopharynx, and three times as likely to be diagnosed with pharynx cancer. More females than males were diagnosed with thyroid cancer and breast cancer, which is very rare in males.

Table 3. Distribution of cancers by sex

Cancer type	Male (%)	Female (%)	Total
Breast	178 (0.7%)	26,469(99.3%)	26,647
Colon	13,589 (54.3%)	11,456 (45.7%)	25,045
Lung	14,500 (53.3%)	12,696 (46.7%)	27,196
Prostate	29,388 (100%)	0	29,388
Liver	1,823 (72.4%)	696 (27.6%)	2,519
Stomach	2,387 (65.9%)	1,237 (34.1%)	3,624
Pharynx	1,620 (75.3%)	531 (24.7%)	2,151
Nasopharynx	290(67.9%)	137 (32.1%)	427
Cervix	0	1,544 (100%)	1,544
Thyroid	660 (26%)	1,883 (74%)	2,543
All cancers	100,066 (52.4%)	90,981 (47.6%)	191,047

Note: The sum of the totals for each cancer type does not equal the total of all cancers, as additional cancers are included in the BC Cancer Registry data that were not examined in the present study.

The cancer data were linked with 2006 Census data for 85 LHAs in BC to include a population of 1,119,215 who self-identified as immigrants. A sociodemographic summary of the study population is presented in Table 4. Within the total population of BC, 89.7% of the population had knowledge of the official language in Canada, speaking English and/or French. Close to one-fifth (19.3%) of the population held a University certificate or degree equivalent to a Bachelor's degree or higher, and nearly one-quarter (24.8%) of the BC population were of visible minority status. The most common visible minority groups included Chinese (40.4%) and South Asian (26%), followed by Filipino (8.7%), Korean (5%), and Southeast Asian (4%).

Of the total 85 LHAs in BC included, just over half (50.6%) were categorized in the lowest income quintile, which translates into an average household income of $39,550 to $59,349. Another 13 LHAs (15.3%) fell within the second income quintile of $59,350 to $63,182. The remaining LHAs were approximately equally distributed into income quintiles 3, 4 and 5. Ten LHAs (11.7%) were in the middle income quintile with an average household income of $63,183 to $66,843 and 9 LHAs (10.6%) fell between $66,844 and $76,311. Only 10 LHAs (11.7%) were categorized in the highest income quintile of $76,312 to $141,821.

The majority of immigrants in BC are established (84.1%), having resided in Canada for more than five years. Immigrants were relatively young at the time of migration. According to the 2006 Census, 40.1% of people who came to BC were in the working age group between 25 and 44 years old. Another 22.8% of immigrants were between the ages of 15 and 24 at the time of migration, and immigrants who arrived as children aged 14 and under accounted for 25.3% of the newcomer population. A smaller proportion (11.8%) of the immigrant population in BC was in the older age group of 45 years and older at the time of arrival.

Most immigrants to BC originated from Asia or Europe. Of the total 1,119,215 immigrants in BC, more than half (54.2%) originated from an Asian country of origin (including the Middle East). Within the immigrant population originating from Asia, the majority (51.7%) reported their birthplace within Eastern Asian countries, including China (24%) and Hong Kong (12.9%). Another 21.9% of Asian immigrants originated from South Asia, primarily India (19.7%), and 19.9% were from Southeast Asia, particularly the Philippines (11.4%). Only 6.5% of Asian immigrants were from West Central Asia and the Middle East. The second largest region immigrants to BC originated from was Europe, with 31.2% of immigrants reporting their birthplace in a European country. Within the immigrant population originating from Europe, the majority of immigrants came from Northern Europe (44.8%), particularly the United Kingdom, where 39.3% of the total European immigrant population originated. Other European immigrants arrived from Western Europe (22.9%), Eastern Europe (17%) and Southern Europe (15.3%), mainly Italy, the birthplace for 5.5% of all European immigrants to BC. Besides Asia and Europe, a small proportion of immigrants to Canada originated from the United States of America (5%), Central America (1.4%), Caribbean and Bermuda (0.8%), South America (1.5%), Africa (3.1%) and Oceania and other areas (2.8%). When countries are classified as more or less developed, 40% of immigrants originated from a developed country, including Europe, United States of America (North America), Australia/New Zealand (Oceania), and Japan.

Recent immigrants who arrived to BC between 2001 and 2006 are more likely to be from Asia. Of the 177,840 recent immigrants in BC, nearly three-quarters (73.4%) originated from an Asian country of origin (including the Middle East), compared to 54.2% of all immigrants. Within the immigrant population originating from Asia, the distribution of where immigrants were born is relatively similar for recent and all immigrants. The only difference appears in Eastern Asia, where more recent immigrants arrived from China (31.8%) and relatively few from Hong Kong (2.3%). With more recent immigrants arriving from Asia, less were arriving from Europe (12.1%).

Within the immigrant population originating from Europe, recent immigrants are much more likely to originate from Eastern Europe compared with all immigrants (42% vs. 17% respectively). In contrast, slightly fewer recent immigrants arrived from Northern Europe compared with all immigrants (32.4% vs. 44.8% respectively), yet the United Kingdom still accounts for most of the recent European immigrant population (30.2%). Overall, fewer recent immigrants were from Western Europe (15.6%) and Southern Europe (10%) compared with all immigrants. Due to the shift in the origins of more recent immigrants from Asian countries, fewer recent immigrants (20.4%) originated from a developed country.

The proportion of immigrants residing in the 85 LHAs across BC varies widely. Immigrant density within LHAs ranged from 1.3% (LHA 92–Nisga'a) to 60% (LHA 166–Vancouver--South). A map of the distribution of immigrant density by LHA in BC is provided in Appendix A.3. An overall description of BC's LHAs by selected immigration variables and sociodemographic factors is provided in Appendix A.4.

Table 4. Sociodemographic summary of study population in BC

Variable		Frequency (%)
Income Quintile Distribution of 85 LHAs		
1 (lowest)		43 (50.6%)
2		13 (15.3%)
3		10 (11.7%)
4		9 (10.6%)
5 (highest)		10 (11.7%)
Time Since Immigration		
5 years or less (recent)		177,840 (15.9%)
More than 5 years (established)		941,365 (84.1%)
Age at Immigration		
Under 5 years		90,155 (8.0%)
5-14 years		193,535 (17.3%)
15-24 years		254,930 (22.8%)
25-44 years		448,475 (40.1%)
45 years and older		132,120 (11.8%)
Region of Birth		
	Recent Immigrants (n=177,840)	**All Immigrants (n=1,119,215)**
North America (USA)	8,175 (4.6%)	56,565 (5.0%)
Central America	3,160 (1.8%)	15,950 (1.4%)
Caribbean and Bermuda	680 (0.4%)	8,575 (0.8%)
South America	3,660 (2.1%)	16,500 (1.5%)
Europe	21,530 (12.1%)	349,405 (31.2%)
Northern Europe	6,980 (32.4%)	156,710 (44.8%)
Eastern Europe	9,045 (42%)	59,320 (17.0%)
Southern Europe	2,150 (10%)	53,400 (15.3%)
Western Europe	3,350 (15.6%)	79,970 (22.9%)
Africa	6,080 (3.4%)	34,575 (3.1%)
Asia and the Middle East	130,620 (73.4%)	606,730 (54.2%)
Eastern Asia	68,070 (52.1%)	313,410 (51.7%)
Southeast Asia	22,390 (17.1%)	120,865 (19.9%)
Southern Asia	27,925 (21.4%)	132,850 (21.9%)
West Central Asia and the Middle East	12,235 (9.4%)	39,600 (6.5%)
Oceania and Other	3,935 (2.2%)	30,910 (2.8%)
Developed Country†	36,345 (20.4%)	447,825 (40%)

Immigrant population estimates are based on the 2006 Census immigrant population total of 1,119,215.
†Developed countries include Europe, North America, Australia/New Zealand (Oceania and Other), and Japan.

4.2 Negative Binomial Regression Models

4.2.1 Research Objective 1: Cancer Incidence by the Proportion of Immigrants

The first research objective of the study was to examine how cancer incidence varied by immigrant concentration in BC regions. Overall, there was a significant association between regional proportion of immigrants and cancer incidence rates in BC. In multivariate negative binomial regression models adjusting for age, sex and income, regional percent concentration of immigrants significantly and negatively predicted the all-cancer incidence rate in BC. Table 5 shows crude and adjusted regression rate ratios (RR) and 95% confidence intervals for cancer incidence rate by proportion of immigrants, adjusting for age, sex and income. Rate ratios are shown graphically in Figure 3. Regression estimates indicate a 10-percent increase in the proportion of immigrants was associated with a 2% decline in the incident rate of all-cancers (RR: 0.98, 95% CI: 0.97-0.99). This reduction in all-cancer rate was observed for both males (RR: 0.97, 95% CI: 0.96-0.97) and females (RR: 0.97, 95% CI: 0.96-0.98). Adjusted RRs and 95% confidence intervals for male and female cancer incidence rates by proportion of immigrants are found in Table 6.

A similar pattern of findings was seen for the four most common cancers of the breast, prostate, colon and lung. In multivariate negative binomial regression models adjusting for age, sex and income, regional percent concentration of immigrants significantly predicted lower cancer incidence rates in BC for cancers of the breast (females), colon, lung and prostate (males). For a 10-percent increase in the number of immigrants residing in LHAs, the incident rate of cancer decreased by 2% for breast (RR: 0.98, 95% CI: 0.97-0.99), 2% for colon (RR: 0.98, 95% CI: 0.97-0.99), 6% for lung (RR: 0.94, 95% CI: 0.93-0.95) and 4% for prostate cancer (RR: 0.96, 95% CI: 0.94-0.97). Similar rates were found for both male and female cancers of the colon and lung. As seen in Table 4 and 5, RRs and corresponding 95% confidence intervals for cancers of the breast, colon, lung and prostate are all less than one, indicating a reduced cancer risk associated with regional immigrant concentration. A similar pattern was seen for cancer of the cervix, as a 10-percent increase in the proportion of immigrants was associated with a 0.02 decrease in the incident count of cancer; however, this association was not significant as the confidence interval included the null value (RR: 0.98, 95% CI: 0.94-1.01).

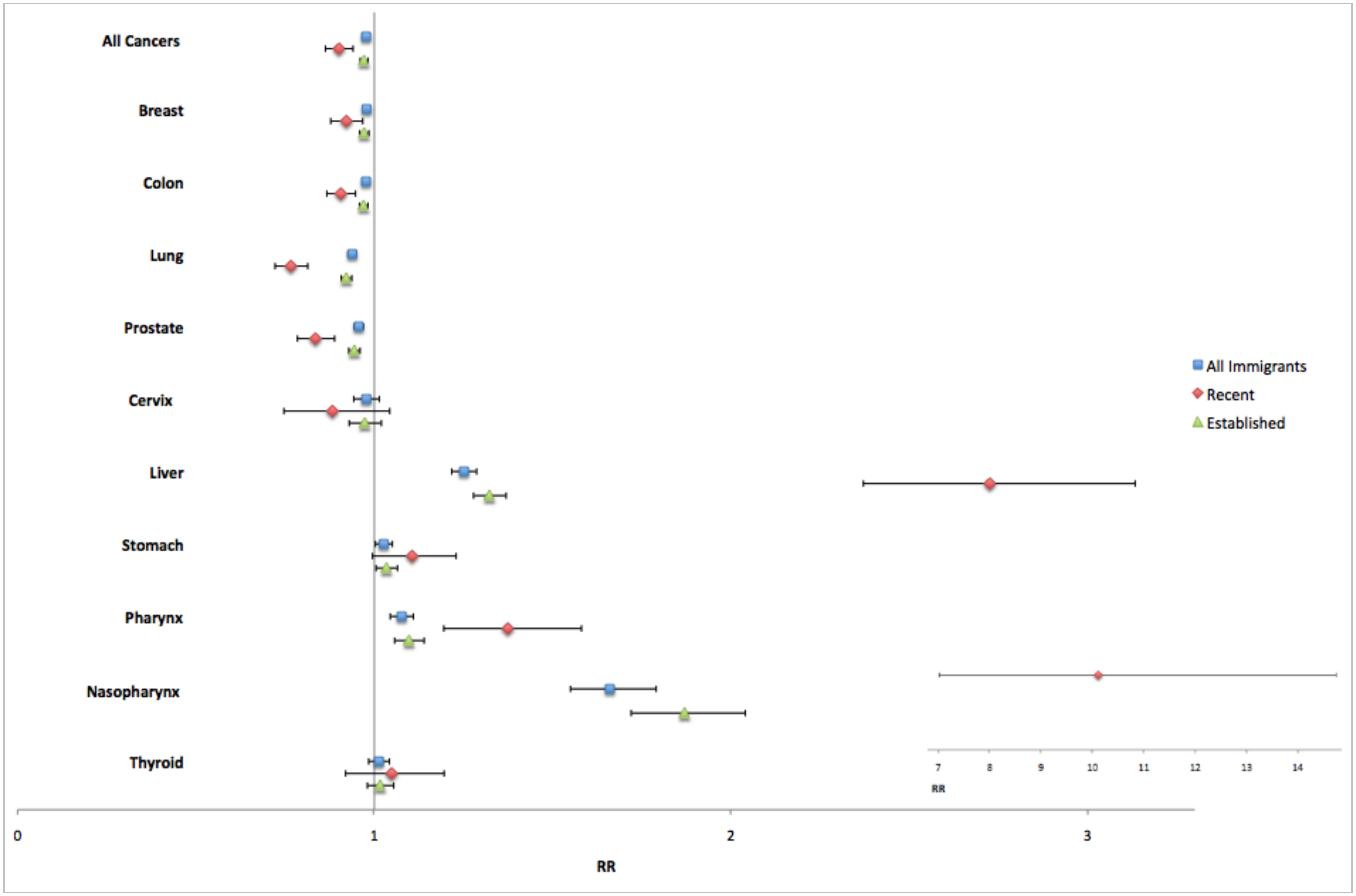
For the less common cancers of the liver, stomach, pharynx and nasopharynx, there was an opposite relationship between the proportion of immigrants and cancer incidence rates; immigrant density significantly and positively predicted cancer incidence in adjusted negative binomial regression models. For every 10-percent increase in the population of immigrants residing in LHAs, the estimated log count of cancer increased by a factor of 0.22, 0.03, 0.08 and 0.51 for cancers of the liver, stomach, pharynx and nasopharynx respectively. That is, the incidence rate of cancer increased by 25% for liver cancer (RR: 1.25, 95% CI: 1.22-1.29), 3% for stomach cancer (RR: 1.03, 95% CI: 1.01-1.05), 8% for pharyngeal cancer (RR: 1.08 95% CI: 1.04-1.11) and 66% for nasopharyngeal cancer (RR: 1.66, 95% CI: 1.55-1.79). Male and female incident rates were alike, except for stomach cancer, where a significant increase was found in females (RR: 1.09, 95% CI: 1.05-1.14) but not males (RR: 0.99, 95% CI: 0.96-1.02). Cancer of the thyroid followed a similar trend, as a 10-percent increase in the proportion of immigrants was associated with a 0.01 increase in the log count of cancer; however, this association was not significant as the confidence interval included the null value (RR: 1.01, 95% CI: 0.98-1.04). Point estimates were also significant in unadjusted univariate regression analyses, providing further evidence of the strong positive association between regional immigrant density and cancers of the liver, stomach, pharynx and nasopharynx.

Table 5. Adjusted rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants for select cancers in BC

		All Immigrants		Males		Females	
Cancer type	**Variable (%)**	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**
All cancers	Total Immigrants	**0.98**	**0.97-0.99**	**0.97**	**0.96-0.97**	**0.97**	**0.96-0.98**
	Recent	**0.90**	**0.86-0.94**	**0.87**	**0.84-0.89**	**0.88**	**0.85-0.90**
	Established	**0.97**	**0.96-0.98**	**0.96**	**0.95-0.96**	**0.96**	**0.95-0.97**
Breast	Total Immigrants	-	-	-	-	**0.98**	**0.97-0.99**
	Recent	-	-	-	-	**0.92**	**0.88-0.97**
	Established	-	-	-	-	**0.97**	**0.96-0.99**
Colon	Total Immigrants	**0.98**	**0.97-0.99**	**0.97**	**0.96-0.98**	**0.98**	**0.97-0.99**
	Recent	**0.90**	**0.87-0.94**	**0.89**	**0.84-0.94**	**0.92**	**0.87-0.98**
	Established	**0.97**	**0.96-0.98**	**0.96**	**0.95-0.98**	**0.98**	**0.96-0.99**
Lung	Total Immigrants	**0.94**	**0.93-0.95**	**0.95**	**0.94-0.97**	**0.92**	**0.91-0.94**
	Recent	**0.76**	**0.72-0.81**	**0.81**	**0.75-0.87**	**0.72**	**0.66-0.77**
	Established	**0.92**	**0.91-0.94**	**0.94**	**0.92-0.96**	**0.90**	**0.88-0.92**
Prostate	Total Immigrants	-	-	**0.96**	**0.94-0.97**	-	-
	Recent	-	-	**0.83**	**0.78-0.89**	-	-
	Established	-	-	**0.94**	**0.93-0.96**	-	-
Cervix	Total Immigrants	-	-	-	-	0.98	0.94-1.01
	Recent	-	-	-	-	0.88	0.75-1.04
	Established	-	-	-	-	0.97	0.94-1.02
Liver	Total Immigrants	**1.25**	**1.22-1.29**	**1.25**	**1.21-1.29**	**1.25**	**1.19-1.32**
	Recent	**2.73**	**2.38-3.14**	**2.70**	**2.31-3.16**	**2.80**	**2.19-3.56**
	Established	**1.32**	**1.28-1.37**	**1.32**	**1.27-1.37**	**1.32**	**1.25-1.41**
Stomach	Total Immigrants	**1.03**	**1.01-1.05**	0.99	0.96-1.02	**1.09**	**1.05-1.14**
	Recent	1.10	0.99-1.22	0.96	0.84-1.09	**1.45**	**1.21-1.75**
	Established	**1.03**	**1.01-1.06**	0.99	0.96-1.03	**1.12**	**1.07-1.18**
Pharynx	Total Immigrants	**1.08**	**1.04-1.11**	**1.07**	**1.03-1.11**	**1.09**	**1.03-1.15**
	Recent	**1.37**	**1.19-1.58**	**1.32**	**1.12-1.55**	**1.50**	**1.15-1.97**
	Established	**1.10**	**1.06-1.14**	**1.09**	**1.04-1.14**	**1.11**	**1.03-1.19**
Nasopharynx	Total Immigrants	**1.66**	**1.55-1.79**	**1.66**	**1.53-1.81**	**1.68**	**1.48-1.90**
	Recent	**10.11**	**7.02-14.74**	**9.32**	**5.99-14.69**	**12.28**	**6.43-23.45**
	Established	**1.87**	**1.72-2.04**	**1.88**	**1.70-2.08**	**1.88**	**1.62-2.18**
Thyroid	Total Immigrants	1.01	0.98-1.04	1.04	0.98-1.09	1.00	0.97-1.04
	Recent	1.05	0.92-1.20	1.11	0.87-1.41	1.03	0.89-1.19
	Established	1.02	0.98-1.05	1.05	0.98-1.12	1.01	0.96-1.05

Statistically significant results in bold.
All immigrant proportion variables run in separate models.
[a] All models adjusted for sex (except for breast, prostate and cervical), age and income.

Figure 3. Rate ratio (RR) of cancer incidence by proportion of immigrants and duration of residence



4.2.2 Research Objective 2: Cancer Incidence by the Proportion of Recent and Established Immigrants

The second research objective was to understand how cancer incidence rates varied by immigrant duration of residence, that is, recent immigrants and long-term immigrants. Interestingly, the significant association between regional proportion of immigrants and cancer incidence rates holds true for both the proportion of recent and established immigrants. Table 5 shows adjusted regression rate ratios and 95% confidence intervals for cancer incidence rates by the proportion of immigrants overall, the proportion of recent immigrants, and the proportion of established immigrants, adjusting for age, sex and income.

Multivariate negative binomial regression models indicated the proportion of recent immigrants who have resided in Canada for less than 5 years significantly and negatively predicted the all-cancer incidence rate in BC. For a 10-percent increase in the proportion of recent immigrants, the estimated risk of all-cancers is reduced by 10% (RR: 0.90, 95% CI: 0.86-0.94). A similar pattern of findings was seen for the four most common cancers of the breast, colon, lung and prostate. For every 10-percent increase in the population of recent immigrants, the incident rate of cancer was reduced by 8% for breast cancer (RR: 0.92, 95% CI: 0.88-0.97), 10% for colon cancer (RR: 0.90, 95% CI: 0.87-0.94), 24% for lung cancer (RR: 0.76, 95% CI: 0.72-0.81) and 17% for prostate cancer (RR: 0.83, 95% CI: 0.78-0.89). Rates differed slightly by sex for lung cancer, with a greater reduced risk of lung cancer found in females (RR: 0.72, 95% CI: 0.66-0.77) compared to males (RR: 0.81, 95% CI : 0.75-0.87). For cancer of the cervix, as a 10-percent increase in the proportion of recent immigrants was associated with a 12% decrease in the risk of cancer; however, the association was not significant as the confidence interval included the null value (RR: 0.88, 95% CI: 0.75-1.04).

Furthermore, the proportion of established immigrants who have resided in Canada for five years or longer also significantly and negatively predicted the all-cancer incidence rate, as well as cancers of the breast, colon, lung and prostate. For a 10-percent increase in the proportion of established immigrants, the incident rate of cancer was reduced by 3% for all-cancers (RR: 0.97, 95% CI: 0.96-0.98**)**, 3% for breast cancer (RR: 0.97, 95% CI: 0.96-0.99), 3% for colon cancer (RR: 0.97, 95% CI: 0.96-0.98), 8% for lung cancer (RR: 0.92, 95% CI: 0.91-0.94) and 6% for prostate cancer (RR: 0.94, 95% CI: 0.93-0.96). As with the proportion of recent immigrants, a 10-percent increase in the proportion of established immigrants was associated with a 3% reduction in the risk of cervical cancer; however, the association was not significant as the confidence interval included the null value (RR: 0.97, 95% CI: 0.94-1.02).

Consistent with the results in the first study objective, an opposite pattern was seen for cancers of the liver, stomach, pharynx, nasopharynx and thyroid. The proportion of recent immigrants who have resided in Canada for less than five years significantly and positively predicted incidence rates of liver, pharyngeal and nasopharyngeal cancer. For a 10-percent increase in the proportion of recent immigrants, the incident rate of cancer increased by 2.7 times for liver cancer (RR: 2.73, 95% CI: 2.38-3.14), 37% for pharyngeal cancer (RR: 1.37, 95% CI: 1.19-1.58) and 10 times for nasopharyngeal cancer (RR: 10.11, 95% CI: 7.02-14.74). The proportion of recent immigrants predicted greater increases in female cancers of the liver, stomach, pharynx and nasopharynx than in males. A 10% increase in the risk of stomach cancer and a 5% increase in the risk of thyroid cancer were also associated with a 10-percent increase in the proportion of recent immigrants; however, these associations were not significant as the confidence interval included the null value (RR: 1.10, 95% CI: 0.99-1.22 and RR: 1.05, 95% CI: 0.92-1.20 respectively).

Similarly, the proportion of established immigrants who have resided in Canada for more than five years also significantly and positively predicted incidence rates of liver, stomach, pharyngeal and nasopharyngeal cancer. For a 10-percent increase in the proportion of established immigrants, the incident rate of cancer increased by 32% for liver cancer (RR: 1.32, 95% CI: 1.28-1.37), 3% for stomach cancer (RR: 1.03, 95% CI: 1.01-1.06), 10% for pharyngeal cancer (RR: 1.10, 95% CI: 1.06-1.14) and 87% for nasopharyngeal cancer (RR: 1.87, 95% CI: 1.72-2.04). Male and female incident rates were alike, except for stomach cancer, where the proportion of established immigrants predicted a significantly higher rate in females (RR: 1.12, 95% CI: 1.07-1.18) but not in males (RR: 0.99, 95% CI: 0.96-1.03). As with the proportion of recent immigrants, there was an increase of 2% in the risk of thyroid cancer for a 10-percent increase in the proportion of established immigrants; however, the association was not significant as the confidence interval included the null value (RR: 1.02, 95% CI: 0.98-1.05). Estimates were also significant in unadjusted univariate regression analyses (except for pharyngeal cancer and recent immigrant proportion), supporting the positive association between regional immigrant density and cancers of the liver, stomach, pharynx and nasopharynx.

When the proportion of recent immigrants and the proportion of established immigrants were entered into the same regression model predicting cancer incidence rates, the proportion of established immigrants remained a significant independent predictor of cancer, predicting reduced cancer rates for breast, colon, lung and prostate and increased cancer rates for liver and nasopharyngeal cancer. The effect for recent immigrants was no longer present. For a summary of regression rate ratios and associated 95% confidence intervals, see Table 6.

Table 6. Adjusted rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for recent and established proportion of immigrants for select cancers in BC

Cancer type	Proportion of Immigrants	RR	95% CI
All cancers	Recent	0.97	0.87-1.09
	Established	0.98	0.95-1.01
Breast	Recent	1.14	0.99-1.30
	Established	**0.94**	**0.91-0.98**
Colon	Recent	1.02	0.91-1.15
	Established	**0.96**	**0.93-0.99**
Lung	Recent	1.10	0.94-1.30
	Established	**0.90**	**0.86-0.94**
Prostate	Recent	1.12	0.95-1.33
	Established	**0.92**	**0.87-0.96**
Cervix	Recent	0.75	0.46-1.21
	Established	1.05	0.92-1.20
Liver	Recent	1.05	0.73-1.51
	Established	**1.31**	**1.19-1.44**
Stomach	Recent	0.88	0.65-1.19
	Established	1.07	0.98-1.16
Pharynx	Recent	0.99	0.67-1.48
	Established	1.10	0.99-1.22
Nasopharynx	Recent	0.80	0.32-1.98
	Established	**1.97**	**1.58-2.46**
Thyroid	Recent	0.92	0.63-1.35
	Established	1.04	0.93-1.15

Statistically significant results in bold.
Models included the proportion of recent immigrants and the proportion of established immigrants in the same model. All models adjusted for sex (except for breast, prostate and cervical), age and income.

4.2.3 Research Objective 3: Cancer Incidence by the Proportion of Immigrants from Particular Age Groups at the Time of Immigration

The third research objective was to understand how cancer incidence rates were associated with the proportion of immigrants from various age groups at the time of the immigration process. In multivariate negative binomial regression models adjusting for age, sex and income, regional percent concentration of age at which immigrants arrived was predictive of cancer incidence rates, although the effects varied by the specific age category and cancer type. A summary of adjusted relative rates and 95% confidence intervals are presented in Table 7. Generally, the proportion of immigrants at a younger age at the time of immigration, particularly under 5 years of age, was significantly associated with an increased all-cancer risk and the risk of cancers of the breast, colon, lung and prostate, but a decreased risk of cancers of the liver, pharynx and nasopharynx. The proportion of immigrants at an older age at arrival, particularly 45 years of age and older, was significantly associated with a decreased all-cancer risk and the risk of cancers of the breast, colon, lung and prostate, but an increased risk of cancers of the liver, pharynx and nasopharynx. The association between age at arrival and stomach cancer is less clear. Despite a lower risk at a younger age of arrival and a higher risk at an older age of arrival, the associations were not significant for all immigrants and the rates for other age groups were inconsistent.[8] The risk of stomach cancer may differ for males and females, as a significant reduction in female stomach cancer was associated with the proportion of immigrants arriving under 5 years of age (RR: 0.77, 95% CI: 0.60-0.97) and a significant increase in female stomach cancer was associated with the proportion of immigrants arriving over 45 years of age (RR: 1.27, 95% CI: 1.08-1.49).

For all-cancers, breast, colon, lung and prostate cancer, a 10-percent increase in the proportion of immigrants who were under five years old at the time of immigration was significantly associated with a higher incident rate of all-cancers (5%), breast (7%), colon (12%), lung (22%) and prostate cancer (12%), whereas a 10-percent increase in the proportion of immigrants who were 45 years of age and older at the time of immigration was significantly associated with a reduced risk of all-cancers (7%), breast (10%), colon (10%), lung (17%), and prostate cancer (14%). This pattern appears to be especially true for female cancers. Overall, as the proportion of immigrants who were under 25 years of age (i.e., <5, 5-14, and 15-24) at arrival

[8] It is possible that the estimates for stomach cancer may not be as reliable because the regression models predicting stomach cancer appeared to be less stable in terms of model fit.

increased, there was an increasing trend in the rate of all-cancers and cancers of the breast, colon, lung and prostate. Once the proportion of immigrants was at the age group of 25 years of age or older (i.e., 25-44 and 45+) at the time of immigration, a decreasing trend in the rate of all-cancers and cancers of the colon, lung and prostate was seen. Despite the clear pattern, not all rate ratios were significant and some confidence interval included the null value.

For cancers of the liver, stomach, pharynx and nasopharynx, a 10-percent increase in the proportion of immigrants who were under five years old at the time of immigration was significantly associated with a reduced incident rate of liver (69%), pharyngeal (31%) and nasopharyngeal cancer (31%), whereas a 10-percent increase in the proportion of immigrants who were 45 years of age and older at the time of immigration was significantly associated with an increased risk of liver (126%), pharyngeal (28%) and nasopharyngeal cancer (5 times greater). For cancers of the pharynx and nasopharynx, the proportion of immigrants arriving under five years age is associated with a significant reduction in male cancer rates, but not a significant reduction in females. Similarly, the proportion of immigrants arriving over 45 years of age is associated with a significant increase in male pharyngeal and nasopharyngeal cancer rates, but only a significant increase in nasopharyngeal cancers in females. In general, a 10-percent increase in the proportion of immigrants who were under 25 years old (i.e., <5, 5-14, and 15-24) at the time of immigration was associated with a reduced incident rate for cancers of the liver, stomach (except for immigrants aged 5-14 years, where an increased rate is seen), pharynx and nasopharynx. An increase in the proportion of immigrants who are 25 years of age or older (i.e., 25-44, 45+) at arrival was associated with a higher incident rate for cancers of the liver, stomach (except for immigrants aged 25-44 years, where a reduced rate is seen), pharynx and nasopharynx. Most of the rate ratios were significant; however, for a few estimates, the confidence interval included the null value.

Table 7. Adjusted rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by age at immigration for select cancers in BC – Separate regression models

		All Immigrants		Males		Females	
Cancer type	**Age at immigration in years (%)**	**RR**	**95% CI**	**RR**	**95% CI**	**RR**	**95% CI**
All cancers	< 5	**1.05**	**1.01-1.08**	**1.08**	**1.05-1.12**	**1.11**	**1.07-1.14**
	5-14	**1.05**	**1.01-1.09**	**1.08**	**1.04-1.11**	**1.09**	**1.05-1.13**
	15-24	1.02	0.99-1.05	**1.05**	**1.03-1.08**	**1.04**	**1.01-1.07**
	25-44	0.98	0.95-1.01	**0.95**	**0.93-0.98**	**0.98**	**0.95-0.99**
	45+	**0.93**	**0.90-0.96**	**0.91**	**0.89-0.93**	**0.88**	**0.86-0.91**
Breast	< 5	-	-	-	-	**1.07**	**1.02-1.13**
	5-14	-	-	-	-	1.05	0.99-1.12
	15-24	-	-	-	-	1.01	0.97-1.05
	25-44	-	-	-	-	1.02	0.98-1.06
	45+	-	-	-	-	**0.90**	**0.86-0.94**
Colon	< 5	**1.12**	**1.07-1.17**	**1.10**	**1.03-1.17**	**1.13**	**1.05-1.22**
	5-14	**1.12**	**1.06-1.18**	**1.10**	**1.03-1.18**	**1.13**	**1.04-1.22**
	15-24	1.02	0.99-1.06	1.05	0.99-1.10	0.99	0.94-1.05
	25-44	0.98	0.94-1.01	0.97	0.92-1.01	0.99	0.94-1.04
	45+	**0.90**	**0.87-0.93**	**0.90**	**0.85-0.94**	**0.91**	**0.86-0.96**
Lung	< 5	**1.22**	**1.15-1.29**	**1.19**	**1.11-1.28**	**1.31**	**1.22-1.41**
	5-14	**1.35**	**1.27-1.44**	**1.30**	**1.20-1.41**	**1.46**	**1.34-1.59**
	15-24	1.05	1.00-1.10	1.02	0.96-1.09	**1.09**	**1.01-1.16**
	25-44	**0.87**	**0.83-0.91**	**0.87**	**0.82-0.92**	**0.85**	**0.80-0.90**
	45+	**0.83**	**0.79-0.87**	**0.89**	**0.84-0.94**	**0.75**	**0.70-0.79**
Prostate	< 5	-	-	**1.12**	**1.05-1.19**	-	-
	5-14	-	-	1.06	0.99-1.14	-	-
	15-24	-	-	**1.13**	**1.08-1.18**	-	-
	25-44	-	-	**0.94**	**0.90-0.98**	-	-
	45+	-	-	**0.86**	**0.82-0.91**	-	-
Cervix	< 5	-	-	-	-	1.07	0.88-1.29
	5-14	-	-	-	-	1.20	0.98-1.48
	15-24	-	-	-	-	0.98	0.85-1.13
	25-44	-	-	-	-	0.93	0.81-1.07
	45+	-	-	-	-	0.98	0.85-1.13
Liver	< 5	**0.31**	**0.26-0.38**	**0.33**	**0.27-0.42**	**0.25**	**0.18-0.36**
	5-14	**0.68**	**0.56-0.82**	**0.67**	**0.55-0.86**	**0.66**	**0.46-0.93**
	15-24	**0.48**	**0.42-0.55**	**0.49**	**0.42-0.56**	**0.46**	**0.36-0.57**
	25-44	**1.63**	**1.43-1.85**	**1.60**	**1.38-1.86**	**1.71**	**1.37-2.15**

	45+	**2.26**	**2.02-2.54**	**2.20**	**1.92-2.51**	**2.41**	**1.97-2.96**
Stomach	< 5	0.96	0.84-1.09	1.06	0.90-1.23	**0.77**	**0.60-0.97**
	5-14	**1.17**	**1.03-1.34**	**1.24**	**1.06-1.46**	1.02	0.80-1.30
	15-24	**0.89**	**0.81-0.98**	0.97	0.87-1.09	**0.75**	**0.63-0.88**
	25-44	0.97	0.89-1.06	**0.89**	**0.80-0.99**	1.15	0.98-1.35
	45+	1.08	0.99-1.19	1.01	0.90-1.13	**1.27**	**1.08-1.49**
Pharynx	< 5	**0.69**	**0.58-0.82**	**0.64**	**0.53-0.79**	0.87	0.62-1.22
	5-14	0.85	0.72-1.02	0.83	0.68-1.02	0.93	0.65-1.32
	15-24	**0.80**	**0.71-0.91**	**0.85**	**0.74-0.97**	**0.68**	**0.53-0.87**
	25-44	**1.24**	**1.10-1.39**	**1.17**	**1.03-1.33**	**1.47**	**1.16-1.87**
	45+	**1.28**	**1.14-1.45**	**1.34**	**1.16-1.52**	1.14	0.90-1.44
Nasopharynx	< 5	**0.69**	**0.58-0.82**	**0.05**	**0.02-0.9**	0.87	0.62-1.23
	5-14	**0.29**	**0.18-0.48**	**0.28**	**0.16-0.50**	**0.31**	**0.14-0.72**
	15-24	**0.80**	**0.71-0.91**	**0.23**	**0.15-0.34**	**0.68**	**0.53-0.87**
	25-44	**4.12**	**2.95-5.81**	**3.85**	**2.56-5.84**	**4.80**	**2.68-8.60**
	45+	**5.42**	**4.00-7.39**	**5.47**	**3.78-7.98**	**5.23**	**3.13-8.74**
Thyroid	< 5	1.03	0.88-1.120	0.94	0.69-1.27	1.04	0.87-1.24
	5-14	1.07	0.90-1.27	1.29	0.93-1.77	0.99	0.82-1.21
	15-24	0.97	0.86-1.08	0.87	0.70-1.05	1.00	0.87-1.13
	25-44	1.02	0.91-1.14	1.08	0.88-1.34	1.00	0.88-1.13
	45+	1.01	0.90-1.13	1.02	0.82-1.27	1.01	0.88-1.15

Statistically significant results in bold.
All immigrant proportion variables were ran in separate regression models for each cancer type.
[a] All models adjusted for sex (except for breast, prostate and cervical), age and income.

When the proportion of immigrants of all age groups except one (15-24 years old) were entered into the same regression model predicting cancer incidence rates, the coefficient for the proportion of immigrants in the oldest age group (45+) remained a significant independent predictor of reduced rates of all-cancers, breast, colon, lung and prostate cancer, and a significant independent predictor of increased rates of liver, stomach, pharyngeal and nasopharyngeal cancer. For cancers of the liver, stomach, pharynx and nasopharynx, the proportion of immigrants who arrived at even younger age groups (i.e., as young as 5+ for liver, stomach and nasopharyngeal cancer, and 25+ for pharyngeal cancer) remained significant positive predictors of incidence rates. The effect of the proportion of immigrants who arrived younger than 5 years of age was no longer significant and the direction of effect changed for some cancer types. For a summary of regression rate ratios and associated 95% confidence intervals, see Table 8.

Table 8. Adjusted rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by age at immigration for select cancers in BC – Same regression model

Cancer type	Age at immigration in years (%)	RR	95% CI
All cancers	< 5	0.99	0.95-1.04
	5-14	1.01	0.97-1.06
	25-44	1.00	0.97-1.03
	45+	**0.93**	**0.88-0.97**
Breast	< 5	0.99	0.90-1.08
	5-14	0.99	0.92-1.07
	25-44	**1.06**	**1.01-1.11**
	45+	**0.87**	**0.82-0.93**
Colon	< 5	1.02	0.93-1.12
	5-14	1.04	0.96-1.13
	25-44	1.02	0.98-1.06
	45+	**0.92**	**0.85-0.99**
Lung	< 5	1.04	0.94-1.14
	5-14	**1.22**	**1.12-1.32**
	25-44	0.95	0.90-1.00
	45+	**0.92**	**0.86-0.99**
Prostate	< 5	0.95	0.86-1.04
	5-14	0.93	0.86-1.01
	25-44	**0.94**	**0.89-0.99**
	45+	**0.83**	**0.77-0.89**
Cervix	< 5	1.04	0.72-1.49
	5-14	1.27	0.97-1.67
	25-44	0.97	0.82-1.16
	45+	1.11	0.86-1.42
Liver	< 5	0.78	0.56-1.08
	5-14	**2.06**	**1.63-2.61**
	25-44	**1.41**	**1.22-1.63**
	45+	**2.38**	**1.97-2.87**
Stomach	< 5	1.02	0.80-1.30
	5-14	**1.42**	**1.19-1.69**

	25-44	0.99	0.89-1.11
	45+	**1.26**	**1.08-1.47**
Pharynx	< 5	0.93	0.68-1.26
	5-14	1.18	0.94-1.49
	25-44	**1.17**	**1.01-1.36**
	45+	**1.25**	**1.02-1.53**
Nasopharynx	< 5	1.49	0.67-3.32
	5-14	**2.24**	**1.14-4.40**
	25-44	**3.58**	**2.41-5.31**
	45+	**6.35**	**3.98-10.12**
Thyroid	< 5	1.13	0.86-1.49
	5-14	1.13	0.91-1.41
	25-44	1.06	0.92-1.21
	45+	1.11	0.91-1.36

Statistically significant results in bold.
All immigrant proportion variables were ran in the same regression models for each cancer type.
[a] All models adjusted for sex (except for breast, prostate and cervical), age and income.

4.2.4 Research Objective 4: Cancer Incidence by the Proportion of Immigrants from Different Countries of Origin

The fourth research objective was to understand how cancer incidence rates varied by the proportion of immigrants from varying countries of origin. Overall, the proportion of immigrants by place of birth significantly predicted cancer incidence rates in BC. Results of negative binomial regression models adjusting for age, sex and income are presented in the following sections for European country of origin, European sub-regions of origin, Asian country of origin, Asian sub-regions of origin, and lastly, developed countries of origin.

4.2.4.1 European Country of Origin

In negative binomial regression models adjusting for age, sex and income, the proportion of immigrants from European countries of origin significantly predicted cancer incidence rates in BC for all cancer types examined, expect for cancers of the cervix and thyroid. The proportion of immigrants from European countries of origin was predictive of significantly increased incidence rates of all-cancer and cancers of the breast, colon, lung and overall and by sex. Table 9 presents rate ratios and 95% confidence intervals for the association between cancer incidence rates and proportion of immigrants by European country of origin. Table 10 shows rates in males and Table 11 shows rates in females. The proportion of immigrants from European countries of origin was predictive of significantly higher incidence rates of all-cancer (RR: 1.02, 95% CI: 1.01-1.03), breast (RR: 1.02, 95% CI: 1.01-1.03), colon (RR: 1.02, 95% CI: 1.01-1.03), lung (RR: 1.03, 95% CI: 1.02-1.04) and prostate (RR: 1.03, 95% CI: 1.02-1.04). In contrast, the proportion of immigrants from European countries of origin was predictive of significantly reduced incidence of cancers of the liver (RR: 0.84, 95% CI: 0.82-0.86), stomach (RR: 0.98, 95% CI: 0.96-0.99), although not in males, pharynx (RR: 0.94, 95% CI: 0.92-0.96) and nasopharynx (RR: 0.67, 95% CI: 0.63-0.71).

4.2.4.1.1 European Sub-Regions of Origin

To further examine the association of European places of birth with cancer risk, a series of negative binomial regression models predicting cancer incidence rate by proportion of immigrants from Northern, Eastern, Western and Southern Europe were ran, adjusting for age, sex and income (see Tables 9, 10 and 11). The proportion of immigrants from Northern Europe consistently and significantly predicted cancer risk for all cancer types; the proportion of immigrants from Northern European origin significantly predicted a higher risk of cancer for all-cancers and cancers of the breast, colon, lung (not for males) and prostate, but predicted a lower risk of cancer for liver, stomach (especially for females), pharyngeal and nasopharyngeal cancers. A similar pattern of association was seen for the proportion of immigrants from Western European origin, except in the case of stomach cancer where, although it predicted a lower risk, it was not a significantly lower risk overall or for males. However, a significant reduction in female stomach cancer was found. The associated reduction in nasopharyngeal cancer with the proportion of immigrants of Western

European origin seemed to be especially strong for males (RR: 0.30, 95% CI: 0.24-0.37) compared to females (RR: 0.85, 95% CI: 0.76-0.95). The proportion of immigrants from Eastern European origin significantly predicted an increased risk of cancers of the breast, colon (not for females) and lung, but a decreased risk of cancers of the liver, pharynx (not for females) and nasopharynx.

Interestingly, the proportion of immigrants from Southern Europe did not follow the same pattern of results as other areas of Europe. The proportion of immigrants from Southern European origin significantly predicted an increased risk of cancers of the colon (not in females) and lung. Europe overall and other sub-regions of Europe showed a reduced risk of stomach, pharyngeal and nasopharyngeal cancers associated with an increase in immigrant percent; however, the proportion of immigrants from Southern Europe was associated with a higher risk of stomach cancer, more so in females (RR: 1.29, 95% CI: 1.12-1.47), as well as potentially higher pharyngeal and nasopharyngeal (not in males) cancers, although these relative incidence rates were not significant. Furthermore, the significantly lower risk of liver cancer seen in all other European regions was not significant for Southern Europe. However, a significant reduction in thyroid cancer in males was associated with the proportion of immigrants of Southern European origin (RR: 0.74, 95% CI 0.58-0.94).

When multivariate Negative Binomial regression models were run with all European sub-regions entered into the same model predicting cancer incidence rates (all but Western Europe), coefficient estimates, RRs and significance remained nearly identical. Increases in the proportion of immigrants of Eastern European origin consistently predicted the greatest increase in rates of breast, colon, and lung cancer, and the greatest reduction in liver, pharyngeal and nasopharyngeal cancers. Increases in the proportion of immigrants of Northern European origin consistently predicted the greatest increase in rates of all-cancers and prostate cancer, and the greatest reduction in stomach cancer, whereas increases in the proportion of immigrants of Southern European origin predicted an increased rate of stomach cancer.

Table 9. Rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by European country of origin for select cancers in BC

	Europe	European sub-region			
		Northern	Eastern	Southern	Western
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
All cancers	**1.02 (1.01-1.03)**	**1.03 (1.02-1.04)**	1.01 (0.97-1.05)	1.01 (0.99-1.03)	**1.02 (1.01-1.04)**
Colon	**1.02 (1.01-1.03)**	**1.02 (1.01-1.03)**	**1.09 (1.04-1.14)**	**1.05 (1.02-1.09)**	**1.03 (1.01-1.04)**
Lung	**1.03 (1.02-1.04)**	**1.03 (1.01-1.04)**	**1.18 (1.11-1.25)**	**1.08 (1.04-1.12)**	**1.07 (1.04-1.09)**
Liver	**0.84 (0.82-0.86)**	**0.78 (0.76-0.81)**	**0.56 (0.47-0.66)**	0.93 (0.83-1.05)	**0.65 (0.61-0.69)**
Stomach	**0.98 (0.96-0.99)**	**0.94 (0.91-0.96)**	1.02 (0.91-1.15)	**1.18 (1.09-1.28)**	0.96 (0.92-1.00)
Pharynx	**0.94 (0.92-0.96)**	**0.93 (0.90-0.96)**	**0.79 (0.67-0.92)**	1.03 (0.92-1.15)	**0.85 (0.80-0.90)**
Nasopharynx	**0.67 (0.63-0.71)**	**0.51 (0.46-0.57)**	**0.19 (0.12-0.30)**	1.03 (0.76-1.36)	-
Thyroid	0.98 (0.96-1.00)	0.97 (0.93-1.00)	0.95 (0.82-1.11)	0.92 (0.82-1.03)	1.00 (0.95-1.05)

Statistically significant results in bold.
All immigrant proportion variables run in separate models. All models adjusted for sex, age and income.

Table 10. Rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by European country of origin for select cancers in BC – Males

	Europe	**European sub-region**			
		Northern	**Eastern**	**Southern**	**Western**
	RR (95% CI)	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**
All cancers	**1.02 (1.02-1.03)**	**1.03 (1.02-1.04)**	**1.04 (1.01-1.08)**	**1.03 (1.01-1.05)**	**1.03 (1.02-1.05)**
Colon	**1.02 (1.01-1.03)**	**1.02 (1.01-1.04)**	**1.11 (1.04-1.18)**	**1.06 (1.02-1.11)**	**1.04 (1.01-1.06)**
Lung	**1.02 (1.01-1.03)**	1.00 (0.99-1.02)	**1.14 (1.05-1.23)**	**1.09 (1.03-1.14)**	**1.04 (1.01-1.07)**
Prostate	**1.03 (1.02-1.04)**	**1.05 (1.03-1.06)**	1.00 (0.94-1.00)	1.01 (0.97-1.06)	**1.05 (1.03-1.08)**
Liver	**0.85 (0.83-0.87)**	**0.79 (0.76-0.83)**	**0.59 (0.48-0.73)**	0.92 (0.80-1.06)	**0.65 (0.61-0.69)**
Stomach	1.00 (0.98-1.02)	**0.97 (0.93-0.99)**	1.12 (0.98-1.29)	**1.13 (1.02-1.24)**	1.02 (0.96-1.07)
Pharynx	**0.94 (0.92-0.97)**	**0.93 (0.89-0.97)**	**0.80 (0.67-0.96)**	1.04 (0.91-1.17)	**0.85 (0.79-0.90)**
Nasopharynx	**0.66 (0.62-0.71)**	**0.52 (0.46-0.59)**	**0.16 (0.09-0.29)**	0.91 (0.60-1.30)	**0.30 (0.24-0.37)**
Thyroid	0.97 (0.93-1.01)	0.96 (0.90-1.03)	0.90 (0.68-1.18)	**0.74 (0.58-0.94)**	0.98 (0.88-1.08)

Statistically significant results in bold.
All immigrant proportion variables run in separate models. All models adjusted for age and income.

Table 11. Rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by European country of origin for select cancers in BC – Females

	Europe	European sub-region			
		Northern	Eastern	Southern	Western
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
All cancers	**1.02 (1.02-1.03)**	**1.04 (1.03-1.04)**	**1.04 (1.01-1.08)**	1.01 (0.99-1.03)	**1.04 (1.03-1.05)**
Breast	**1.02 (1.01-1.03)**	**1.03 (1.02-1.05)**	**1.08 (1.03-1.14)**	1.01 (0.98-1.05)	**1.03 (1.01-1.05)**
Colon	**1.01 (0.99-1.02)**	**1.02 (1.01-1.04)**	1.05 (0.98-1.13)	1.04 (0.99-1.09)	1.01 (0.99-1.04)
Lung	**1.05 (1.04-1.07)**	**1.05 (1.03-1.07)**	**1.26 (1.16-1.37)**	**1.10 (1.04-1.16)**	**1.11 (1.07-1.14)**
Cervix	1.00 (0.98-1.03)	1.01 (0.96-1.05)	0.88 (0.72-1.06)	0.99 (0.86-1.13)	1.03 (0.96-1.10)
Liver	**0.84 (0.80-0.87)**	**0.76 (0.71-0.81)**	**0.48 (0.35-0.65)**	0.96 (0.77-1.18)	**0.64 (0.58-0.71)**
Stomach	**0.94 (0.91-0.96)**	**0.88 (0.84-0.92)**	0.83 (0.67-1.03)	**1.29 (1.12-1.47)**	**0.85 (0.78-0.92)**
Pharynx	**0.94 (0.90-0.98)**	**0.93 (0.87-0.99)**	0.76 (0.55-1.03)	1.01 (0.80-1.25)	**0.85 (0.76-0.95)**
Nasopharynx	**0.67 (0.61-0.75)**	**0.48(0.39-0.58)**	**0.25 (0.11-0.57)**	1.22 (0.77-1.94)	**0.85 (0.76-0.95)**
Thyroid	0.99 (0.96-1.01)	0.97 (0.93-1.01)	0.98 (0.83-1.16)	0.99 (0.87-1.13)	1.00 (0.94-1.06)

Statistically significant results in bold.
All immigrant proportion variables run in separate models. All models adjusted for age and income.

4.2.4.2 Asian Country of Origin

In negative binomial regression models adjusting for age, sex and income, the proportion of immigrants from Asian countries of origin significantly predicted cancer incidence rates in BC for all cancer types examined, expect for cancers of the cervix and thyroid. Table12 presents rate ratios and 95% confidence intervals for the association between cancer incidence rates and proportion of immigrants by Asian country of origin. The opposite pattern of associations is seen in cancer incidence rates for immigrants originating from Asian countries compared with European countries. The proportion of immigrants from Asian countries of origin is predictive of significantly decreased incidence rates of all-cancer (RR: 0.99, 95% CI: 0.98-0.99) and cancers of the breast (RR: 0.98, 95% CI: 0.98-0.99), colon (RR: 0.99, 95% CI: 0.98-0.99), lung (RR: 0.97, 95% CI: 0.96-0.98) and prostate (RR: 0.97, 95% CI: 0.96-0.98). The proportion of immigrants from Asian countries of origin is predictive of significantly increased incidence of cancers of the liver (RR: 1.16, 95% CI: 1.14-1.18), stomach (RR: 1.02, 95% CI: 1.01-1.04), although not in males, pharynx (RR: 1.05, 95% CI: 1.03-1.07), and nasopharynx (RR: 1.40, 95% CI: 1.34-1.47).

4.2.4.2.1 Asian Sub-Regions of Origin

To further examine the association of Asian places of birth with cancer risk, a series of negative binomial regression models predicting cancer incidence rate by proportion of immigrants from East Asia, Southeast Asia, South Asia and West Central Asia (including the Middle East) was run, adjusting for age, sex and income (see Table 12). Table 13 shows rates in males and Table 14 shows rates in females. The proportion of immigrants from East Asia and Southeast Asia consistently predicted cancer incidence rates for all cancer types; the proportion of immigrants from East Asian and Southeast Asian origins significantly predicted a lower risk of cancer for all-cancers and cancers of the breast, colon, lung and prostate, but predicted a higher risk of cancer for liver, stomach (not in males), pharyngeal and nasopharyngeal cancers. The effects of the proportion of immigrants from West Central Asia on cancer incidence rates were consistent with the overall pattern of findings for Asian origin; however, rates were only significantly lower for lung cancer (not in females) and significantly higher for liver and nasopharyngeal cancers. For these Asian sub-regions, the incident rate of liver cancer was 21% higher for a 10-percent increase in the proportion of immigrants of East Asian origin (RR: 1.21, 95% CI: 1.18-1.24), 72% higher for Southeast Asian origin (RR: 1.72, 95% CI: 1.61-1.84), and 44% higher for West Central Asian origin (RR: 1.44, 95% CI: 1.23-1.68). Another significantly strong effect was evident for cancer of the nasopharynx. The incident rate of nasopharyngeal cancer was 51% higher for a 10-percent increase in the proportion of immigrants of East Asian origin (RR: 1.51, 95% CI: 1.43-1.59), more than three times higher for Southeast Asian origin (RR: 3.08, 95% CI: 2.63-3.63), and 76% higher for West Central Asian origin (RR: 1.76, 95% CI: 1.17-2.63).

The proportion of immigrants of South Asian origin did not follow the same pattern of results as other areas of Asia. Increases in the proportion of immigrants from Asia overall and all other sub-regions of Asia was associated with an increased risk of liver, stomach, pharyngeal and nasopharyngeal cancers; however the proportion of immigrants from South Asia was associated with a reduced risk of these cancers. Interestingly, the proportion of immigrants of South Asian origin significantly predicted a 6% lower risk of liver cancer (7% in males, but not significant for females) and a 17% lower risk of nasopharyngeal cancer, two cancers that have otherwise demonstrated a significantly increased risk in Asian originating immigrant populations thus far. This reduction in nasopharyngeal cancer appeared to be even stronger for females, with a 33% reduction associated with a 10-unit increase in immigrant density, but the association was not significant for males).

When multivariate Negative Binomial regression models were run with all Asian sub-regions entered into the same model predicting cancer incidence rates (all but West Central Asia), coefficient estimates, RRs and significance remained nearly identical. Increases in the proportion of immigrants of Southeast Asian origin consistently predicted the greatest increase in rates of liver, stomach, pharyngeal and nasopharyngeal cancers, and the greatest reduction in breast cancer rates. Increases in the proportion of immigrants of Eastern Asian origin is also quite a strong predictor for increased rates of liver and nasopharyngeal cancers, and consistently predicted the greatest reduction in rates of all-cancers, colon, lung and prostate cancers.

Table 12. Adjusted rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by Asian country of origin for select cancers in BC

	Asia	**Asian sub-region**			
		East	**Southeast**	**South**	**West Central**
	RR (95% CI)	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**	**RR (95% CI)**
All cancers	**0.99 (0.98-0.99)**	**0.89 (0.97-0.99)**	**0.96 (0.94-0.98)**	0.99 (0.98-1.01)	0.96 (0.93-1.01)
Colon	**0.99 (0.98-0.99)**	**0.99 (0.98-0.99)**	**0.96 (0.94-0.99)**	**0.98 (0.97-0.99)**	0.96 (0.93-1.00)
Lung	**0.97 (0.96-0.98)**	**0.96 (0.95-0.98)**	**0.95 (0.92-0.98)**	0.98 (0.96-1.00)	**0.85 (0.80-0.90)**
Liver	**1.16 (1.14-1.18)**	**1.21 (1.18-1.24)**	**1.72 (1.61-1.84)**	**0.94 (0.89-0.99)**	**1.44 (1.23-1.68)**
Stomach	**1.02 (1.01-1.04)**	**1.03 (1.01-1.05)**	**1.14 (1.07-1.20)**	0.97 (0.94-1.00)	1.06 (0.96-1.18)
Pharynx	**1.05 (1.03-1.07)**	**1.07 (1.04-1.09)**	**1.25 (1.16-1.34)**	0.98 (0.93-1.02)	1.10 (0.96-1.27)
Nasopharynx	**1.40 (1.34-1.47)**	**1.51 (1.43-1.59)**	**3.08 (2.63-3.63)**	**0.83 (0.72-0.94)**	**1.76 (1.17-2.63)**
Thyroid	1.01 (0.99-1.03)	1.02 (0.99-1.04)	1.06 (0.99-1.14)	0.98 (0.94-1.02)	1.15 (1.02-1.30)

Statistically significant results in bold.
All immigrant proportion variables run in separate models. All models adjusted for sex, age and income.

Table 13. Adjusted rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by Asian country of origin for select cancers in BC – Males

	Asia	Asian sub-region			
		East	Southeast	South	West Central
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
All cancers	**0.98 (0.98-0.99)**	**0.97 (0.97-0.98)**	**0.95 (0.93-0.96)**	1.00 (0.99-1.01)	**0.97 (0.95-0.99)**
Colon	**0.98 (0.98-0.99)**	**0.98 (0.97-0.99)**	**0.96 (0.92-0.99)**	0.99 (0.97-1.00)	1.00 (0.95-1.05)
Lung	**0.98 (0.97-0.99)**	**0.98 (0.97-0.99)**	1.01 (0.97-1.05)	0.98 (0.96-1.01)	**0.94 (0.88-0.99)**
Prostate	**0.97 (0.96-0.98)**	**0.95 (0.94-0.97)**	**0.91 (0.88-0.94)**	1.02 (1.00-1.04)	0.97 (0.93-1.02)
Liver	**1.15 (1.13-1.18)**	**1.21 (1.18-1.24)**	**1.70 (1.58-1.83)**	**0.93 (0.88-0.99)**	**1.17 (1.01-1.35)**
Stomach	1.00 (0.98-1.02)	1.00 (0.98-1.03)	1.02 (0.95-1.10)	0.99 (0.95-1.03)	1.04 (0.93-1.15)
Pharynx	**1.05 (1.03-1.07)**	**1.06 (1.03-1.09)**	**1.26 (1.16-1.36)**	1.00 (0.95-1.05)	1.03 (0.90-1.18)
Nasopharynx	**1.41 (1.34-1.50)**	**1.49 (1.40-1.59)**	**3.26 (2.72-3.94)**	0.91 (0.77-1.06)	1.11 (0.73-1.62)
Thyroid	1.03 (0.99-1.06)	1.05 (1.00-1.10)	1.11 (0.96-1.28)	0.94 (0.87-1.01)	1.11 (0.91-1.33)

Statistically significant results in bold.
All immigrant proportion variables run in separate models. All models adjusted for age and income.

Table 14. Adjusted rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by Asian country of origin for select cancers in BC – Females

	Asia	Asian sub-region			
		East	Southeast	South	West Central
	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)	RR (95% CI)
All cancers	**0.98 (0.98-0.99)**	**0.98 (0.97-0.98)**	**0.94 (0.92-0.95)**	**0.99 (0.98-0.99)**	0.98 (0.96-1.01)
Breast	**0.98 (0.98-0.99)**	**0.98 (0.98-0.99)**	**0.93 (0.90-0.96)**	**0.98 (0.97-0.99)**	0.99 (0.95-1.03)
Colon	**0.99 (0.98-0.99)**	1.00 (0.99-1.01)	0.98 (0.94-1.01)	**0.97 (0.95-0.99)**	0.96 (0.91-1.01)
Lung	**0.96 (0.95-0.97)**	**0.95 (0.93-0.96)**	**0.87 (0.85-0.93)**	0.98 (0.95-1.01)	0.98 (0.92-1.05)
Cervix	0.99 (0.97-1.01)	0.99 (0.96-1.02)	0.98 (0.89-1.07)	1.00 (0.95-1.06)	0.92 (0.79-1.07)
Liver	**1.17 (1.13-1.20)**	**1.21 (1.16-1.25)**	**1.75 (1.56-1.95)**	0.94 (0.86-1.03)	**1.25 (1.01-1.54)**
Stomach	**1.06 (1.04-1.09)**	**1.09 (1.05-1.12)**	**1.38 (1.26-1.51)**	**0.94 (0.89-0.99)**	1.05 (0.89-1.22)
Pharynx	**1.05 (1.01-1.09)**	**1.09 (1.04-1.14)**	**1.22 (1.06-1.40)**	**0.90 (0.82-0.99)**	1.12 (0.88-1.40)
Nasopharynx	**1.39 (1.28-1.51)**	**1.55 (1.41-1.70)**	**2.77 (2.09-3.68)**	**0.67 (0.52-0.87)**	1.42 (0.91-2.21)
Thyroid	1.01 (0.99-1.03)	1.01 (0.98-1.03)	1.05 (0.97-1.14)	0.99 (0.94-1.03)	1.11 (0.98-1.24)

Statistically significant results in bold.
All immigrant proportion variables run in separate models. All models adjusted for age and income.

When multivariate Negative Binomial regression models were run with the proportion of both European and Asian originating immigrants entered into the same model predicting cancer incidence rates, RRs and the associated confidence intervals changed for many of the cancer types examined (see Table 15). Increases in the proportion of immigrants of European origin continued to predict a significant increased risk in the incidence rate of all-cancers and breast cancer. Increases in the proportion of immigrants of Asian origin continued to predict a significant reduction in the incidence of liver and nasopharyngeal cancer.

Table 15. Adjusted rate ratio (RR) and 95% confidence interval (CI) of cancer incidence for proportion of immigrants by European and Asian country of origin for select cancers in BC

Cancer type	Proportion of immigrants by country of origin	RR	95% CI
All cancers	European	**1.024**	**1.01-1.04**
	Asian	1.005	0.99-1.02
Breast	European	**1.046**	**1.01-1.08**
	Asian	1.021	0.99-1.05
Colon	European	1.023	0.99-1.06
	Asian	1.004	0.98-1.03
Lung	European	1.006	0.97-1.04
	Asian	0.977	0.95-1.01
Prostate	European	1.00	0.97-1.04
	Asian	0.98	0.95-1.01
Cervix	European	0.89	0.79-1.00
	Asian	**0.90**	**0.81-0.99**
Liver	European	1.04	0.93-1.17
	Asian	**1.20**	**1.09-1.32**
Stomach	European	1.02	0.93-1.11
	Asian	1.04	0.96-1.11
Pharynx	European	0.98	0.88-1.09
	Asian	1.03	0.94-1.13
Nasopharynx	European	1.15	0.78-1.70
	Asian	**1.57**	**1.14-2.16**
Thyroid	European	0.94	0.85-1.03
	Asian	0.96	0.88-1.05

Statistically significant results in bold.
Proportion of immigrants from European and Asian countries of origin run in the same model.
All models adjusted for sex (except for breast, prostate and cervical), age and income.

4.2.4.3 Developed Country of Origin

When country of origin was categorized by development (i.e., proportion of immigrants from a developed country), the same pattern and direction of associations was demonstrated as was found for the proportion of immigrants from European countries of origin. As previously mentioned, developed countries include North America, Europe, Australia, New Zealand, and Japan. For a 10-percent increase in the proportion of immigrants originating from a developed country, cancer incidence rates were significantly higher for all-cancers (RR: 1.01, 95% CI: 1.01-1.02), breast (RR: 1.02, 95% CI: 0.99-1.02), colon (RR: 1.01, 95% CI: 1.01-1.02), lung (RR: 1.03, 95% CI: 1.02-1.03) and prostate (RR: 1.02, 95% CI: 1.01-1.03). There was a similar increase in cervical cancer incidence rate, although this increased risk was not significant (RR: 1.01, 95% CI: 0.99-1.03). In contrast, a 10-percent increase in the proportion of immigrants originating from a developed country was associated with significantly lower cancer rates for cancers of the liver (RR: 0.86, 95% CI: 0.85-0.88)), stomach (RR: 0.98, 95% CI: 0.97-0.99), pharynx (RR: 0.95, 95% CI: 0.93-0.97) and nasopharynx (RR: 0.71, 95% CI: 0.70-0.75). A similar effect was seen for thyroid cancer, although this reduced risk was not significant (RR: 0.99, 95% CI: 0.97-1.01). When cancer incidence rates were examined by sex for developed country of origin, rate ratios and associated 95% confidence intervals were nearly identical for all cancers with the same pattern of results, except for stomach cancer in males, where a significantly lower risk was not observed.

Chapter 5: Discussion

5.1 Summary of Findings

Although immigrants may experience an overall health advantage compared to Canadian-born residents upon arrival, this benefit tends to diminish over time and is dependent on a number of factors. Cancer is a complex disease and contributions to risk emerge from determinants occurring both prior to and following the migration experience. Further complicating our understanding of cancer risk is the heterogeneity within the immigrant population to BC, as immigrants have resided in the province for varying amounts of time, arrived at different ages, and originated from diverse locations across the globe. Using 10-year cancer incidence data from the BC Cancer Registry and Census data on immigrant status, this study is one of the first to explore the association of regional immigrant concentration with cancer risk in BC in a number of different ways, considering duration of residence, age at immigration and country of origin in the calculation of the proportion of immigrants. Understanding the contribution of these factors on the cancer risk of immigrants in BC is necessary for the development of age, generational, and culturally appropriate health plans, programs, and policies designed to improve cancer risk and prevention in this population.

Overall, the findings demonstrate a significant association between regional proportions of immigrants and cancer incidence rates in BC. A reduced risk of cancer is associated with increased regional immigrant density for all-cancers and common cancers of the breast, colon, lung and prostate. In contrast, an increased cancer risk is associated with immigrant density for cancers of the liver, stomach, pharynx and nasopharynx. Interestingly, these site-specific cancers tend to be less common cancers in Western society, yet there is evidence of higher rates of these cancers among certain immigrant populations, particularly those born in Asia (Jemal et al., 2007). Within the immigrant population in BC, subgroup analyses reveal differences in cancer incidence rates by self-reported age at immigration, country of origin and years since migration, again highlighting the heterogeneous nature of this population. Both recent and established immigrants appear to benefit from an overall reduced cancer risk, as well as immigrants who migrate from Asian countries of origin and arrive at an older age. The findings and implications of this research will be discussed in relation to existing literature in the following sections, followed by a review of the strengths and limitations of the study and directions for future work.

5.1.1 Cancer Incidence by Proportion of BC Immigrants

The results indicate that regional proportion of immigrants significantly and negatively predicts all-cancer incidence rates in BC. As immigrant concentration increases among LHAs, there is an overall reduction in the incidence rate of all-cancers. This finding is consistent with the literature examining cancer among immigrant populations across Canada, as a reduced all-cancer risk has been documented for cancer incidence (Hyman, 2007; Carriere et al., 2013; McDermott et al., 2011; Luo et al., 2004; Yavari et al., 2006; Hislop et al., 2007; Luo et al., 2004). Interestingly, similar findings of the present ecological-based approach to understanding the relationship between immigrant status and cancer have been demonstrated across a number of national Canadian studies using various sources of data, timeframes, statistical analyses, and methodological approaches, including ecological-based research (e.g., Carriere et al., 2013), cross-sectional (e.g., McDonald & Kennedy, 2004) and longitudinal cohort studies (e.g., McDermott et al., 2011; Sheth et al., 1999). Although there is a lower risk of cancer incidence among immigrants overall, the effects vary by cancer type.

Considering specific cancer sites, immigrant concentration is associated with lower cancer incidence rates for breast, colon, lung and prostate cancers (McDermott et al., 2011; Carriere et al., 2013; Gomez et al., 2013). In contrast, increases in immigrant concentration are associated with higher cancer incidence rates for liver, stomach, pharyngeal and nasopharyngeal cancers. This pattern of lower risk of all-site and the most common cancers is reflected in the literature (McDermott et al., 2011; Carriere et al., 2013; Gomez et al., 2013), as is the higher risk of cancers of the liver (Chen et al., 2008; Jiang et al., 2011 McDermott et al., 2011; DesMeules et al., 2005; Carriere et al., 2013), stomach (Trovato, 2003; Balzi et al., 1995), pharynx and nasopharynx (Dermott et al., 2011; Carriere et al., 2013; DesMeules et al., 2005).

These findings are consistent with the only other study known to date to examine cancer incidence by proportion of immigrants. In a recent national Canadian study examining cancer incidence rates by terciles of the foreign-born population, lower age-standardized incidence rates of all-site cancers were found among areas with a higher concentration of foreign-born populations compared with areas of lower concentration of foreign-born (Carriere et al., 2013). The same pattern was evident both nationally and provincially for lung, colorectal, prostate and female breast cancers. In contrast, an inverse pattern was observed nationally for cancers of the liver, nasopharynx, and thyroid where higher rates of cancer incidence were found among highly concentrated foreign-born populations. Unique to the present study is the inclusion of province-specific data for cancers of the liver, nasopharynx, and thyroid in BC.

Somewhat surprisingly, the present study did not find evidence of a higher risk of thyroid cancer among more immigrant-dense regions as did Carriere et al. (2013), yet uniquely, there is evidence of a higher incidence of stomach and pharyngeal cancer which was not reported by Carriere. These are not necessarily unexpected findings given the evidence in the literature of higher stomach cancer mortality in immigrants (Balzi et al., 1995; Trovato, 2003), and a higher risk of both nasopharyngeal cancer (Carriere et al., 2013; McDermott et al., 2011; Luo et al., 2004; DesMeules et al., 2005) and oropharyngeal cancer (Auluck et al., 2010) in immigrants and ethnic minorities, as both nasopharyngeal and oropharyngeal cancers are specific sites within the broader tumour group of pharyngeal cancer.

5.1.2 Cancer Incidence by the Proportion of Recent and Established Immigrants

Consistent with the pattern of findings in the first research objective, the proportion of immigrants by years since migration predicted cancer incidence rates in BC. Regardless of whether immigrants have lived in their new country of destination for less than 5 years or more than 5 years, they appear to carry a reduced risk of developing all-cancers and cancers of the breast, prostate, colon and lung, while concurrently carrying an increased risk for developing cases of liver, stomach, pharyngeal and nasopharyngeal cancers in BC. McDonald and Neily (2011) similarly did not observe a significant difference between recent immigrant women and those who had been in the US for 15 years or more, although more established immigrant women did have a higher odds of being diagnosed with cancer. Other research tends to show an overall reduction in the health of immigrants over time, with health status and cancer risk converging toward that of the host population (e.g., McDonald & Kennedy, 2004; Myers & Rodriguez, 2003; Kliewer & Smith, 1995a; 1995b).

Although both recent and established immigrants appear to benefit from a reduced risk of cancer incidence, there is a gap between rates, where the cancer risk is especially reduced among recent immigrants and is subsequently higher among more established immigrants. One possible explanation for this difference is that recent immigrants tend to be younger (Ip, 2008), and therefore are likely to have lower rates of cancer. There also tends to be a greater proportion of Asian-born immigrants in LHAs with a high proportion of immigrants (see Appendix A.3) and recent immigrants are more likely to be Asian-born (Ip, 2008), which may help to account for the larger estimates for recent immigrants compared to total or more established immigrants. Asian-born populations appear to carry a reduced risk of some of the most common Western cancers, which may account for the overall reduced rates of cancer incidence seen in areas with higher concentrations of immigrants.

Alternatively, this observed gap between cancer rates of recent and established immigrants may also reflect the effects of acculturation or assimilation on immigrants' cancer risk. This shift or rise in cancer risk with longer duration of residence in the host country may be interpreted as providing suggestive evidence of the processes of acculturation, whereby migrants adopt the lifestyle, beliefs, and health practices of the host society, and over time, approximate the health and cancer profile of the Canadian-born population. Other research comparing the self-reported health status of recent and established immigrants in Canada has found evidence of acculturation and lifestyle changes over time (Subedi & Rosenberg, 2014). It has generally been demonstrated that when immigrants adopt the lifestyle and diet of the host country, their risk of cancer is more similar to the new host country rather than their country of origin (World Cancer Research Fund/American Institute for Cancer Research, 2007). Although this is possibility, the current study did not look at changes over time or the effects of immigrant generation on cancer risk (i.e., cancer rates in migrant offspring), and therefore definitive evidence or claims of acculturation cannot be made. The proportion of established immigrants who have been in Canada for longer than 5 years do still appear to carry a health advantage for several cancers in BC, despite cancer rates fading slightly in magnitude from the rates associated with the proportion of recent immigrants.

When the proportion of recent immigrants and established immigrants were entered into the same regression model predicting cancer incidence, the proportion of established immigrants remained a significant independent predictor of cancer while the effect for recent immigrants was no longer seen. In this case, established immigrants experienced a reduced risk of breast, colon, lung and prostate cancer, as well as an increased risk of liver and nasopharyngeal cancer, but the same effect was not seen for recent immigrants. Thus, the proportion of established immigrants may be a stronger predictor of cancer incidence rates in BC compared with a proportion of recent immigrants. However, it is also possible that the composition of the recent and established immigrant groups differ by another important factor, such as ethnic origin. The proportion of established immigrants represents a much larger group of immigrants compared to recent immigrants across LHAs in BC (see Appendix A.3), and therefore likely carries a greater weight when predicting cancer rates. A larger proportion of immigrants may also represent more Asian originating immigrants, which may help to account for the pattern of findings regarding the reduced risk of more common Western cancers and an increased risk of cancers considered "high risk" among Asian populations (Jemal et al., 2007).

5.1.3 Cancer Incidence by the Proportion of Immigrants from Particular Age Groups at the Time of Immigration

Overall, increases in the proportion of immigrants who migrate at a younger age, particularly under five years of age, is associated with an increased all-cancer risk and the risk of cancers of the breast, colon, lung, and prostate, but a reduced risk of less common cancers of the liver, stomach, pharynx and nasopharyx. In contrast, increases in the proportion of immigrants who migrate at an older age, particularly 45 years of age and older, is associated with a reduced all-cancer risk and the risk of cancers of the breast, colon, lung, and prostate, but an increased risk of cancers of the liver, stomach, pharynx and nasopharyx. The effect of age at arrival for stomach cancer is less clear. For cancers of the lung and prostate, the reduced cancer risk experienced by immigrants may be apparent at an even younger age of arrival compared to all-cancers, breast and colon, perhaps as early as 25 years of age and older. For cancers of the liver, pharynx and nasopharynx, the increased cancer risk experienced by immigrants may emerge as early as 25 years of age and older. Even when immigrants arrive to Canada as young as 25 years of age (and older), they still appear to carry their original risk of cancer with them to the host country, that is, a reduced rate of lung and prostate cancer but an increased rate of liver, pharyngeal and nasopharyngeal cancer. This pattern is indicative of the possible role of genetic predisposition interacting with the influential role of environmental exposures associated with ones' origin on the risk of these types of cancers.

When the proportion of immigrants of all age groups except one (15-24 years old) were entered into the same regression model predicting cancer incidence rates, the proportion of immigrants in the oldest age group (45+) remained a significant independent predictor of cancer while the effect for the proportion of immigrants who arrived younger than 5 years of age was no longer significant. In this case, the proportion of immigrants who arrived 45 years of age or older experienced reduced rates of all-cancers, breast, colon, lung and prostate cancer, but increased rates of liver, stomach, pharyngeal and nasopharyngeal cancer. Thus, the proportion of immigrants who arrive at an older age, particularly 45 years of age and older, appears to be a stronger predictor of cancer incidence rates in BC.

Other research has found that the age of the migrant at the time of the immigration process is an important factor on cancer risk (e.g., Balzi et al., 1995; Ziegler et al., 1993). In a study of breast cancer risk among Asian American women, Ziegler found the risk of breast cancer declined steadily as women migrated at older ages, particularly older than 35 years of age. Balzi also found when Italians immigrated to Canada at a younger age, their risk of cancer was more similar to that of the host population. A similar effect is observed in the current study. Individuals who immigrate at an older age have been exposed to the risks in their originating country longer, meaning it is more likely that they uptake and maintain that degree of risk in the new country of destination (e.g., liver cancer). At the same time, older migrants may be less biologically sensitive to the environmental exposures and carcinogens in the West, or they may be more reluctant to change their traditions and customs and adopt Western lifestyles, possibly accounting for their overall reduced risk of cancer. Conversely, when a greater proportion of immigrants arrive at a younger age, cancer risk seems to gradually increase over time and converge toward the cancer rates in the host country. Not only is there a shorter duration of exposure to risk factors in the originating country, this trend may suggest some degree of acculturation, whereby younger migrants adapt to or identify with the new culture more readily, assuming the lifestyle behaviours and cancer risk profile of the Canadian-born population. Experts in the field tend to agree that age at the time of immigration and length of time in the new country and culture are important indicators of acculturation (Phinney, 2003).

5.1.4 Cancer Incidence by the Proportion of Immigrants from Different Countries of Origin

5.1.4.1 European Country of Origin and Cancers of the Lung, Breast, Colon and Prostate

Cancer incidence rates appear to vary by immigrant country of origin. The proportion of immigrants from European and developed countries significantly predicted higher incidence of all-cancer and cancers of the breast, colon, lung and prostate, but lower incidence of cancers of the liver, stomach, pharynx and nasopharynx, which is consistent with the overall literature (e.g., Carriere et al., 2013; McDermott et al., 2011). In a recent study of cancer patterns across 40 countries in Europe, the most common cancers included breast, colorectal, prostate and lung (Ferlay et al., 2013). Increases in the proportion of immigrants of Eastern and Northern European origins consistently predicted the greatest increases in rates of breast, colon, and lung cancer, and the greatest reduction in liver, stomach (Northern Europe only), pharyngeal and nasopharyngeal cancers (see Appendix B.1 for a list of countries included within the regions of Europe). Generally, health status, cancer risk, and health care services among more developed countries tend to be similar; therefore, we would expect to see a more similar cancer risk profile in European and North American countries than in non-European and North American countries. The elevated cancer rates associated with European immigrants are consistent with the more common cancers observed in Western society. For instance, literature suggests prostate cancer is most common in North-Western Europe (along with North America) and less common in Asia, Africa, Central America, and South America (American Cancer Society, 2014), a trend that is reflected in the current study. Eastern Europeans of Jewish decent have one of the highest rates of colorectal cancer of any ethnic group in the world, generally attributable to genetic mutations (American Cancer Society, 2014). Interestingly, the highest incidence of colon cancer in the present study is also seen among immigrants of Eastern European origin. Prostate and colorectal cancer are both cancers attributable to inherited or genetic risk factors, physical inactivity, obesity, and Westernized diets that are high in read meats and low in fruit and vegetable intake (Flood et al., 2000; Gotay, 2010; Canadian Cancer Society, 2015; American Cancer Society, 2014). Colorectal cancer is also linked with smoking and heavy alcohol use.

Similarly, breast cancer tends to be more common among Caucasian women, whereas Asian, Hispanic, and Native American women have a lower risk of developing and dying from breast cancer (American Cancer Society, 2014). Family history and genetic risk factors, physical inactivity, obesity, and alcohol consumption, as well as potentially diet, tobacco smoke, and exposures in the environment are associated with increased breast cancer risk (Gotay, 2010; American Cancer Society, 2014). In terms of lung cancer, differences in smoking and diet (low in fruit and vegetables and high in red meat consumption) are likely accountable for the higher observed rates among European-originating immigrants and lower rates among immigrants of Asian origins found in the present study. In one Canadian study, immigrants were less likely than Canadian-born to have ever smoked; however, whereas Asian immigrants were much more likely to have never smoked, (75% recent and 62% long-term immigrants versus 34% Canadian-born), levels of smoking were quite a bit higher among European immigrants with only 56% of recent and 38% of long-term immigrants having never smoked (Chen et al., 1996a). That said, research suggests rates of smoking are decreasing in more recent decades in North America and some European countries, particularly among men (Shafey et al., 2003; Gotay, 2010).

A unique difference emerged in the cancer rates for Southern Europe. The proportion of immigrants from Southern Europe was associated with a higher risk (18%) of stomach cancer overall, particularly in females (29%), as well as potentially higher pharyngeal and nasopharyngeal cancers, although not significant. Furthermore, the significantly lower risk of liver cancer seen in all other European regions was not significant for Southern Europe. Immigrants from Southern Europe are primarily from Italy. In a Canadian study of Italian migrants to Canada, Balzi et al. (1995) similarly found a significantly higher risk for stomach cancer in Italian migrants, both for males (OR: 1.87, 95% CI: 1.73-2.02) and females (OR: 2.43, 95% CI: 2.18-2.71).

5.1.4.2 Asian Country of Origin and Cancers of the Liver, Stomach, Pharynx and Nasopharynx

Contrary to European country of origin, the proportion of immigrants from Asian countries of origin predicted lower incidence of all-cancer and cancers of the breast, colon, lung and prostate, but higher incidence of cancers of the liver, stomach, pharynx and nasopharynx, a pattern consistent with the literature (McDermott et al., 2011; Carriere et al., 2013; DesMeules et al., 2005). The proportion of immigrants from East Asian and Southeast Asian origins were consistently strong predictors of an increased risk of liver, stomach, pharyngeal and nasopharyngeal cancers (see Appendix B.2 for a list of countries included under Asian origins). Incidence rates of liver and nasopharyngeal cancers are substantially higher for the proportion of immigrants from Asia overall, and those of East, Southeast and West Central Asian origins. Similarly, Canadian studies show high incidence and mortality rates for liver and nasopharyngeal cancers, especially for Southeast Asian and Northeast Asian[9] immigrants (McDermott et al, 2011; DesMeules et al., 2005), and particularly high oropharyngeal and nasopharyngeal cancer among males (Auluck et al., 2010; DesMeules et al., 2005). A similar trend is prevalent in the US, where liver cancer incidence is higher among Asian immigrants, particularly Filipino (i.e., Southeast Asian), Chinese (East Asian) and Japanese (Northeast or East Asian) populations (Rosenblatt, Weiss, & Schwartz, 1996;

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[9] In some studies, Northeast Asia is used to classify Japan and Korea. In the current study, Canadian Census data includes these countries under East Asia.

American Cancer Society, 2014). Nasopharyngeal cancer is nearly twice as common in males as females, and is most common in China, including Hong Kong, (East Asia) and Southeast Asian countries such as Singapore, Vietnam, Malaysia, and the Philippines (American Cancer Society, 2014). The present study not only found a high incidence in males, but a strong association was seen in females as well, particularly for immigrants of East and Southeast Asian origin.

The incident rate of stomach cancer was also significantly higher among Southeast Asian and East Asian immigrants. Most cases (72%) of stomach cancer occur in developing countries, with half of all incident cases occurring in Eastern Asia, mainly China and Korea (Globocan, 2015; Tung, 2012). In one study in the United States, incidence rates of stomach cancer are two to three times higher among Asian Pacific Americans than Whites (Tung, 2012). Interestingly, the proportion of immigrants of South Asian origin (including India) appeared to be associated with a significantly lower risk of liver and stomach cancers, two cancers that have otherwise demonstrated an increased risk in Asian-originating immigrant populations, perhaps due to lower rates of exposure to associated viral and bacterial infections, including Hepatitis viruses (B and C) and Helicobacter pylori (H. pylori).

Several studies in the literature attribute the lower health status among European originating immigrants and simultaneous health advantage among non-European or Asian originating immigrants to be due to the age profile of these different groups of immigrants, such that recent immigrants tend to be younger (Ip, 2008). Unfortunately, the present study did not have data on the current age profiles of immigrants, so this potential association cannot be examined. However, given much of the research on cancer risk and the association with immigrants' originating countries and cancer rates in those countries, it seems unlikely that age alone is responsible. Ethnic profiles may also be a contributing factor, as recent immigrants tend to be from Asian origin given the shifts in Canadian immigration policy (e.g., Carriere et al., 2013; Newbold & Danforth, 2003; Kobayashi, 1998). Immigrants' country of origin largely determines exposure to certain living conditions and lifestyles, viruses, bacteria, and potential genetic predisposition to diseases in certain ethnic groups, all of which have been demonstrated to be associated with or casually linked to certain types of cancers that are often more prevalent in Asian countries.

The findings in the present study are likely attributable to different genetic, environmental and lifestyle factors suspected to influence cancers such as breast, prostate, colon, lung, liver, stomach, and pharyngeal/nasopharyngeal cancers. Many of the well-established risk factors and exposures affiliated with high incident cancers in BC are exposures that would occur in immigrants' country of origin prior to arrival. For instance, the high risk of liver, stomach, pharyngeal and nasopharyngeal cancers among Asian immigrants may reflect a past exposure or infection in the country of origin, such as viral infection by Hepatitis-B and C or parasitic infection (Rosenblatt et al., 1996; McDermott et al., 2011; DesMeules et al., 2005), H. pylori infection (National Cancer Institute, 2003; Tung, 2012), HPV (Auluck et a., 2010), or Epstein-Barr virus (DesMeules et al., 2005). Evidence suggests that among developing countries, these infection-related cancers are disproportionately high (Gotay, 2010). Nasopharyngeal cancer is also associated with excessive exposure to dust and smoke and diets high in salt-preserved foods (McDermott et al., 2011; Luo et al., 2004). Similarly, stomach cancer may be attributed to diets typical in Asia that contain smoked, pickled and preserved foods high in salt and nitrates. Smoking can also harm the membrane of the stomach, and one US-based review suggests rates of smoking are higher among some Asian Pacific Americans, such as Korean (36%) and Vietnamese (30.9%) American men, compared with White men (18.7%) (McCracken et al., 2007).

5.1.4.3 Non-Significant Associations – Cervical and Thyroid Cancer

Somewhat surprisingly, results from the current study did not show a significantly elevated risk of cervical cancer incidence associated with regional immigrant density. Some literature suggests rates of cervical cancer are higher among immigrant populations compared with native-born Canadians (McDermott et al., 2011; Hislop, Mumick, & Yelland, 1995), especially immigrants from South Asia (Grewel et al., 2004; Hislop et al., 1995). Cervical cancer is associated with the sexually transmitted human papilloma virus (HPV). Rates of participation in Pap screening programs tend to be lower among immigrant women compared with the general population (Canadian Partnership Against Cancer, 2014; Lofters, Hwang, Moineddin, & Glazier, 2010), particularly South Asian women (Lofters et al., 2007), although this gap appears to narrow over time as participation rates among established immigrants become more similar to the Canadian-born population (Latif, 2010; Khadilkar & Chen, 2013). In addition, recent immigration, visible minority status, speaking a foreign language, low income and low education are associated with significantly lower rates of Pap screening (Lofters et al., 2007; Latif, 2010).

Although the relative risk of cervical cancer was not significant in this study, results suggest a potentially greater risk among European-originating immigrants and a lower risk among Asian-originating immigrants. Contrary to the body of work discussed here, this pattern is consistent with findings of a Swedish study of cervical cancer where a higher relative risk was found among women from Denmark, Norway, and Central America, but a lower relative risk was evident among immigrants from Eastern Africa, South Central Asia, and South Western Asia (Azerkan et al., 2008). Over time (10 or more years), cervical cancer rates tended to converge towards the native Swedish-born population, with rates among European women decreasing and rates among Asian women increasing. It would be interesting to follow the women in our study to assess time trends to see if a similar pattern emerges in BC. Furthermore, in a report by the World Cancer Research Fund and the American Institute for Cancer Research (2007), China was among the countries with the lowest rates of cervical cancer. Of the immigrants originating from Asia in the current study, most (51.7%) are from East Asia, primarily China and Hong Kong, which may help to account for the lower cervical cancer rates observed among Asian originating immigrants in the present study.

Overall, regional concentration of immigrants also did not significantly predict thyroid cancer; however, one significant reduction in the incidence rate of thyroid cancer was found in men of South European origin. Other studies have found evidence of a higher risk of thyroid cancer among some immigrant populations, particularly those of Asian descent and Italian origin, although findings tend to be mixed (Carriere et al., 2013; Balzi et al., 1995; Rossing, Schwartz, & Weiss, 1995). In one study of Italian migrants to Canada, the risk of thyroid cancer was significantly higher in female migrants (OR: 1.71, 95%CI: 1.16-2.54), which is typical with the higher thyroid rates in Italy (Balzi et al., 1995). In a study of Asian migrants to the US, Filipino-born men and women had a higher rate of thyroid cancer compared to US-born Whites (RR: 2.6, 95% CI: 1.9-3.6 and RR: 3.2, 95% CI: 2.7-3.8 respectively); however, no clear pattern of association was seen among Chinese migrants and the risk varied among Japanese migrants, with some evidence of a higher risk among Japanese-born women compared to US-born women (RR: 1.4, 95% CI: 1.0-2.1). Overall, the incidence of thyroid cancer among these Asian residents of the US tends to be higher than incidence rates in the corresponding countries of origin (Rossing et al., 1995). The primary risk factor for thyroid cancer is exposure to radiation, particularly to the head and neck region and at a young age, although there are also a number of hereditary conditions associated with thyroid cancer (American Cancer Society, 2014).

It is possible that the immigrant density variables used in this study are too general of a measure to capture the nuances and multitude of competing influences on the risk of these less common types of cancer risk among immigrant populations. Furthermore, the proportion of recent immigrants represented such a small percentage of the population that it may not have been sufficient to distinguish the potentially higher cervical or thyroid cancer rates associated with it. With the proportion of established immigrants (whose risk of cancer may be more similar to the general Canadian population) heavily weighting the proportion of immigrants variable, an overall association of cervical or thyroid cancer risk may not have been able to be detected.

5.2 Strengths and Limitations

There are several strengths of the study. This is one of the first studies to examine overall and cancer-specific incidence in BC by regional immigrant density while considering the influence of important factors that have not been consistently examined in other research. This study builds on existing national research by Carriere and colleagues to offer a more detailed analysis of immigrant cancer risk in BC while considering the associations with country of origin, age at immigration and duration of residence, as well as adjusting for the partially confounding effect of regional income. Regional-level estimates of income did matter in regression models predicting cancer rates, indicting it is an important variable to adjust for. The current study used a large population based multi-ethnic sample from the BC Cancer Registry and Canadian Census. Use of the BCCR offers accurate, pathologically verified data on cancer cases in contrast to self-reported data on overall health that are commonly used in other studies. A random sample of Canadian residents is selected to complete the census (required by law), and therefore selection bias (i.e., bias in how study participants are selected) and non-response bias among potential study participants (i.e., different response rates among subjects by socioeconomic, sociodemographic, lifestyle or cultural factors) are not major threats. As Carriere and colleagues highlight, this type of ecologically-based approach using regional density from the census offers a unique and valuable method for disease surveillance when individual-level data are inaccessible or data linkage not feasible, particularly in the case of immigrant status variables in Canada where the national or provincial cancer registries do not collect information on immigration history, race, or ethnicity.

The regional-level analysis is meaningful at the population-level and LHA health planning. Although many of the regression estimates and associated incidence rate ratios in this study sample are relatively small, these estimates are meaningful at the larger population-level. For example, even though there is a seemingly small increase in liver cancer risk of 0.0224 for a 1-percent change in immigrant population density, this change is important when we consider the large population it is relevant to. In a LHA such as Richmond, where immigrants account for 57% of the population, this type of increased risk for liver cancer is of particular concern.

Study results should be interpreted in light of several limitations. First, this study is an ecological or correlation study and individual-level data on immigrant status were not available. The cross-sectional nature of the data precludes causal inferences. For instance, the direction of effects, such as whether persons at a lower risk of cancer have a tendency to settle in high immigrant dense areas, or whether other additional uncontrolled factors are responsible for the observed effects, cannot be determined. Mechanisms or pathways through which the regional proportion of immigrants impacts cancer incidence are unknown, and data on important factors such as the use of healthcare services, including cancer screening, level of acculturation, and lifestyle behaviours of immigrants were not available. Like much of the literature on cancer risk among immigrants, controlling for the countless potential confounding factors that contribute to the health of immigrants over time was not possible. While not providing evidence for causation, this type of ecologically-based observational study generates knowledge and hypotheses for possible links between specific factors and cancer outcomes. Furthermore, the strong significant pattern of findings is this study is generally consistent with the large body of research examining immigrant cancer incidence in Canada using a number of other sources of provincial, national and international data and rigorous study designs examining cohorts and changes over time. However, despite the coherent pattern of associations, it is important to note the findings may not be generalizable beyond BC.

Second, caution regarding data interpretation is necessary as the study is subject to the ecological fallacy: drawing inferences about individuals based on the analysis of group data. The immigrant population residing in LHAs across BC is a heterogeneous group, differing across many characteristics that affect health. Immigrants from Asian countries of origin are presumed to have similar exposures, risks and behaviours; however, the experiences of individuals may not be the same or generalizable across the group. Furthermore, income is defined by LHA rather than at an individual level in the present study. Although providing a useful overall average of the socioeconomic position of most inhabitants in the area, this approaches assumes all individuals residing in any given LHA have the same status, when in fact many people will be living in conditions better or worse than the average. Japanese immigrants tend to have higher SES and are often more acculturated compared to other Asian migrants such as individuals from China (McCracken et al., 2007), yet both are grouped under the same "East Asia" category in the present study.

Third, the categorization of variables in the Census dataset may have masked important differences among subgroups, such as specific racial/ethnic groups or countries of birth. The current study offers a more detailed analysis of country of origin; however, country classifications still aggregate many ethnic origins into broad groups, which may have resulted in attenuated effect sizes. There may be other subtleties in country of origin not captured here, such that immigrants' country of departure may be more useful than country of birth to truly understand cancer risk associated with environmental exposures related to origin. The classification of recent and established immigrants by a five-year marker may have precluded finding larger differences in cancer risk between the two groups. Non-permanent residents, including refugees, were not included in the current study, but some research suggests the health status of refugees tends to be more similar to that of immigrants than native-born populations (Gushulak et al., 2011; McDermott et al., 2011). Lastly, the use the percent variables challenged the examination of multiple variables within one regression model. Future research using multivariate analysis is needed to understand more about which regional-level immigrant factors are "independently" associated with cancer risk.

The geographic boundaries within which health and census data are collected and aggregated may not necessarily be meaningful at the level of communities, or be related to the distribution of populations such as immigrants. The readily available boundaries predefined by

LHAs may not reflect socially relevant communities and the concentration of immigrants around meaningful focal points of community activities, resources, and shared identity, beyond simple residence in a certain geographic area. It is well established in the literature that there are neighbourhood-level associations with health, and research suggests the concentration of immigrants in residential communities may be influential on health behaviours, beliefs and practices (Pan & Carpiano, 2013; Osypuk et al., 2009), yet the geographic areas defined by health service boundaries may not coincide with or capture more naturally occurring neighbourhoods and ethnic enclaves, or be meaningful beyond the provision of health services. However, the regional data by LHA are practical for assessing health needs in the province.

Another limitation regarding the nature of the data is the years of data for immigrant status and cancer counts do not coincide wholly, such that immigrant density in 2006 is used to predict cancer rates from 2000 to 2009. It is unlikely that we are predicting cancer rates for those same immigrants included in the proportion measurements due to the nature of cancer (highly associated with increasing age) and the possibility that people may have moved (e.g., immigrants living in a certain LHA at the time of the census may not be there at a later date at the time of a cancer diagnosis). However, given the mobility status within the past year at the time of the 2006 Census and the fact that most people did not migrate (83%), this is not a large concern when examining immigrant populations in Canada. Within five years of the census, the large majority (77%) of migrants continued to remain not only within Canada, but also intra-provincially (Citizenship and Immigration Canada, 2013).

Lastly, as with much of the research on immigrant health, immigrants' cohort and time effects are likely confounded. Since immigration patterns in Canada have changed substantially in more recent decades, it is difficult to draw conclusions by comparing the health status of recent and long-term immigrants because they not only differ by length of time in Canada, but also other factors specific to that cohort of immigrants arriving, such as originating country.

In spite of these methodological and data limitations, the present study provides insight about the cancer risk of the immigrant population, describing several aspects of the immigrant experience in BC. This study offers knowledge about the overall and cancer-specific incidence patterns associated with immigrant density in BC, an area where little research has been reported.

5.3 Implications and Recommendations

Given the findings, several implications and recommendations follow suit concerning cancer inequalities and cautions around the language of labeling of "healthy immigrants," local health planning implications and prevention recommendations, and implications for health and immigration policy.

5.3.1 Cancer Inequalities and Implications of Labeling "Healthy Immigrants"

Understanding the health and cancer risk of immigrants is important as Canada is a major immigrant-receiving country and immigrants represent a large proportion of the BC population. This is a population deserving attention as it may experience vulnerabilities in that some immigrants may be more susceptible to certain cancers in the new country of residence due to predisposing genetic factors or exposures in their country of birth, while simultaneously being exposed to a new set of risk factors in the host country such as unhealthy lifestyle factors or barriers to accessing health care services. There are inequalities in the risk of cancer as immigrants not only arrive with a higher risk of cancer types that are more prevalent in their originating country, but research suggests their cancer risk also increases over time for common cancers in Western society (McCracken et al., 2007; Gomez et al., 2013). In this respect, immigrant populations potentially carry double the risk, suggesting the choice of wording and labeling around "the healthy immigrant effect" may be dangerous and inaccurate as evidence suggests the phenomenon is not true for all types of cancer, or for immigrants of all ages and across all countries of origin. If we assume all immigrants are healthier than Canadian-born, efforts for appropriate cancer care, resources and services will be insufficient, potentially jeopardizing the health of such a large segment of the population.

5.3.2 Implications for LHA Health Planning and Prevention Recommendations

Findings from this study are meaningful at the LHA level and have important implications for regional health planning and services. It is worthwhile to note that experts in the field regard incidence-based measures of population health more relevant to the planning of prevention activities, whereas other measures such as prevalence are useful for the planning of treatment and rehabilitation services (Murray, Salomon, & Mathers, 2000). Although it is estimated that at least 50% of cancers can be prevented through modifiable risk factors (Gotay, 2010; Colditz et al., 2006), many individuals have misconceptions about cancer risk and prevention, including modifiable lifestyle factors (e.g., Choudhry et al., 1998; Johnson et al., 1999; Bottorff et al., 1998). For example, residents of Canada have relatively low awareness about the risks of cancer and symptoms (14%) and perceive barriers to receiving cancer care (21%) (Forbes et al., 2013). Some ethnic groups have less knowledge and education about cancer, risk factors and preventability, and the availability of screening programs or other health services (McDonald & Kennedy, 2004; Choudroy et al., 1998; Gupta et al., 2002). For instance, in a study of knowledge, attitudes, beliefs and practices about breast cancer screening in South Asian immigrants to Canada, Choudroy found most women had little knowledge about breast cancer and rates of participation in screening were low. Furthermore, only 5% of these women thought cancer could be cured. Fatalistic beliefs about cancer prevention and feeling a lack of personal control over reducing one's own risk of cancer are negatively associated with healthy lifestyle behaviours such as eating five or more fruits and vegetables daily, exercising weekly, or not smoking (Niederdeppe & Gurmankin Levy, 2007). Furthermore, these misconceptions may be exacerbated when coupled with potential differences in immigrants' cultural beliefs and practices, language challenges, and reduced health literacy, which may create barriers in accessing health services, including cancer screening (Choudhry et al., 1998; Gupta et al., 2002; Hislop et al., 2003).

With the large proportion of immigrants residing in some LHAs and evidence of the strong association between immigrant density and some types of cancer, LHA and associated health service delivery areas may need to adapt their cancer control strategies accordingly. Understanding the specific cancer risk of immigrant sub-groups and tailoring information for education and prevention efforts involves knowledge of factors such as originating country. Cancers common among European-born immigrants, such as breast, colon, lung and prostate, are associated with lifestyle behaviours, along with genetic factors. Thus, prevention recommendations center on improving lifestyle factors such as not smoking, limiting alcohol consumption, being physically active, and improving diet through increased fruit and vegetable intake and limiting red meat.

In contrast, cancers common among Asian-born immigrants, including liver, stomach, pharynx and nasopharynx, tend to be linked with exposure to viruses and bacteria that are more typical in Asian or developing countries, as well as dietary factors, smoking, and genetic components. In this case, prevention recommendations focusing on vaccinations for the Hep B virus and HPV, changing dietary practices to reduce consumption of foods that are smoked, pickled and preserved with salt and nitrates, encouraging food safety and immediate treatment of bacterial infections (H. pylori) with antibiotics, and minimizing exposure to dust and smoke all assume priority status. Although many of these exposures are ones that would occur in immigrants' countries of origin prior to arrival, education to improve awareness and modify necessary behaviours following migration remains essential. For instance, vaccinations for the Hep virus should be encouraged if individuals are not already immunized to help reduce the threat of liver cancer. Appropriate changes to diet, food preparation and preservation are also important at any time, as is minimizing exposure to dust and smoke, including smoking tobacco, all of which are modifiable risk factors associated with stomach and nasopharyngeal cancers.

Increases in cancers common in Western society have also been observed with younger age at arrival, increasing length of residence in the host country, and future generations among Asian immigrants (McCracken et al., 2007; Gomez et al., 2013). Some literature attributes these changes to processes of acculturation, whereby migrants adopt the lifestyle behaviours, attitudes, and health practices of the host society (Phinney, 2003). Therefore, continued information and education on maintaining good health through healthy lifestyle choices and the use of health services, including cancer screening, is important for all immigrants, as well the general population of BC. The changing trends in immigrants' country of origin has had a fairly dramatic influence on the proportion of recent immigrants who are arriving from Asian countries, which may impact the types of cancers we see becoming more prevalent in Canada. Past trends that have been observed in cancer risk may not necessarily be the same cancer risk profiles we see in the future, which will have implications for local health authority planning.

5.3.3 Policy Implications

Understanding the cancer risk among immigrants in BC is an important first step not only for improving cancer prevention efforts, but also for informing policy in order to reduce or prevent cancer disparities in immigrant populations. Although immigrants appear to demonstrate a reduced risk of cancer overall in BC, the higher incidence of certain cancers and the potentially higher risk with increasing years since migration is concerning and suggests the need for policies to direct attention toward the maintenance and promotion of immigrant health. Immigrants often experience a different set of influences on their health compared with native-born Canadians, including unique social determinants of health, health beliefs and practices, and access to health services, all of which may impact lifestyle behaviours and cancer risk. These differing influences call for policies relating to immigrant health and wellbeing at multiple levels, across a range of different sectors and stakeholders. For instance, policy changes are needed not only at the government level, such as Citizenship and Immigration Canada, to help facilitate immigrant transition, settlement and encourage multiculturalism, but also at the level of the community and non-governmental organizations that offer a range of educational, recreational, cultural and health services. Some policies and programs provide support to immigrants at the broader population-level, such as universal employment programs, food security, or information and health education materials that have been translated into multiple languages. Other supports are offered at an individual-level, such as a community cooking programs, language classes or career skills and training workshops. Policies and programs may also be directed at specific groups within the immigrant population, such as specific ethnic communities. For example, Chinese community supports and services such as the Chinese Cultural Centre of Greater Vancouver offers ethnic classes and programs in the arts and languages, while the Canadian Mental Health Association offers a specific Pathways Clubhouse for Chinese Support to support Chinese mental health and culturally appropriate activities. No matter what the level of policy or program, all are focused on contributing to the wellbeing among immigrants.

One level of policy addresses broader determinants of health and socio-economic factors, such as income and employment. These conditions likely contribute to changes in the overall health status of immigrants, as immigrants tend to earn less than their Canadian-born counterparts and suffer from underemployment, often due to challenges integrating into the labour market and receiving recognition of academic credentials (e.g., Panzenboeck, 2009; Hyman, 2007). General Ministry of Health programs, such as Employment and Income Assistance, and other government organizations (e.g., Welcome BC Skills Connect for Immigrants Program) and non-governmental organizations (e.g., Immigrant Services Society and MOSAIC) can help to address barriers immigrants encounter in finding and training for a career.

Education and health promotion about cancer risks and prevention can be addressed by multiple sectors. At an early point of contact, such as during the immigration process, the Citizenship and Immigration Canada office provides an opportunity to offer education and health promotion about cancer risks and prevention to help reduce immigrants' cancer risk for certain types of cancer they may be more susceptible to. Alternatively, immigrants may be more receptive to educational health information once settled in the new host country, suggesting outreach through non-profit community services (e.g., REACH Community Health Centre) and community ethnic supports (e.g., Family Services of Greater Vancouver) may also be important avenues of contact. If the deterioration of immigrants' health over time is not effectively prevented, there will be additional burdens on the health care system. With cancer continuing to be the number one cause of death among Canadian adults, it is essential that immigrants have access to appropriate information and services for health and cancer prevention. Health policy makers at the government or immigration level have the potential to address issues such as language and cultural barriers to immigrants' understanding of the risk factors associated with cancer, cancer prevention and access to services by providing culturally and linguistically appropriate health information materials, particularly for the Asian and Chinese-speaking community.

Programs and policies that facilitate healthy integration and encourage multiculturalism are also essential across government, non-government and community organizations. Immigrants are likely to live in neighborhoods with other migrants and members of their ethnic group upon arrival to their receiving country (Iceland & Scopilliti, 2008; Logan et al., 2002). The results of this study show that living in immigrant-dense regions, compared to living in regions with fewer immigrants, is associated with cancer risk. Since acculturation and ethnic identity can be thought of as multidimensional processes involving identification with or retention of the original culture and identification with or adaptation to the new host culture (Phinney, 2003), there may be different strategies to or degrees of acculturation, some of which may be more advantageous for health

(Berry, 2005). Different modes of adaptation include assimilation, integration, separation and marginalization. Generally, immigrants who integrate experience less stress and achieve better adaptation (Berry, 2005). For instance, "integrated" acculturated Chinese immigrants may be more likely to choose to live in Chinese dense regions (Hyman, 2001). These types of ethnic enclaves may have beneficial aspects and signify positive acculturation, whereby individuals preserve some of their traditional culture while also adopting some parts of the new society. Immigrant density has also been found to be negatively associated with acculturation, suggesting that immigrant enclaves may mediate the relationship between acculturation and worsening health among immigrants by potentially slowing down the processes of acculturation (Hochhausen et al., 2010). Understanding the specific factors at play and the pathways through which regional context matter for immigrant cancer risk are important for understanding the health of different ethnic groups. These mechanisms may also suggest strategies for creating neighborhood environments that are conducive to health among not only immigrants, but all BC residents. National policies established through Citizenship and Immigration Canada, and local programs such as S.U.C.C.E.S.S. that encourage multiculturalism and support immigrants in maintaining their ethnic heritage and positive health practices may lead to a positive acculturative experience with beneficial health effects in the long-term. New immigrants would also benefit from community programs or interventions that facilitate positive integration into the new society, especially within the first five years after migration, such as the services offered through non-governmental organizations like MOSAIC and **AMSSA** that support immigrant settlement, integration and building culturally inclusive communities. There is a need for stronger links between research, policy and the delivery of services to assist immigrants in their transition to Canada and Western culture, with the potential for reducing their cancer risk. Table 16 summarizes examples of multi-sector immigrant supports in the Greater Vancouver Area, involving multiple players or stakeholders across the government and immigrant sector, health care sector, community and non-profit organizations.

Table 16. Examples of multi-sector stakeholders and immigrant supports in the Greater Vancouver Area

Sector	Service, Program or Support
Government of Canada	**Citizenship and Immigration Canada** – Federal government ministry responsible for setting national policy on immigration, refugee assistance, sponsorships and claims, temporary residence, permanent residence and citizenship, immigrant settlement, and multiculturalism. **Immigrant Employment Council of BC (IEBC)** – Working with BC's business community to encourage the growth of employment opportunities for immigrants. **HealthLinkBC** – Health guides and nutrition information translated into multiple languages, including Chinese, Punjabi, French, Spanish and Vietnamese.
Ministry of Health	**Vancouver Coastal Health (VCH)** – One of five publicly funded regional health authorities in BC. E.g., Bridge Community Health Clinic – Primary and preventive health care services for new immigrants and refugees to Canada. **Welcome BC** – A comprehensive website with information on resources and programs for newcomers to BC. E.g., The Skills Connect for Immigrants program (Skills Connect) is an individualized employment bridging program that helps skilled immigrants connect to jobs in B.C. that build on their pre-arrival skills, training, knowledge, and experience.
Non-Governmental Organization	**AMSSA (Affiliation of Multicultural Societies and Services Agencies of BC)** – Provincial association that is an affiliation of over 75 multicultural agencies providing immigrant settlement and multicultural services to build culturally inclusive communities throughout BC. **REACH Community Health Centre** – A non-profit, community-governed organization that meets the medical, dental, and cultural needs of the community. E.g., Multicultural Family Health Project – Assists individuals and families from diverse cultural backgrounds to receive the health services they require by helping to remove systemic barriers and enhance their ability to participate in the health care systems. **MOSAIC (Multilingual Orientation Service Association for Immigrant Communities)** – A multilingual non-profit organization dedicated to addressing issues that affect immigrants and refugees in the course of their settlement and integration into Canadian society. E.g., Offers services and programs for settling in Canada, learning English, finding and training for a job. **S.U.C.C.E.S.S.** – A non-profit social service agency that promotes the wellbeing of Canadians and immigrants, and encourages their full participation in community affairs in the spirit of multiculturalism. E.g., Services range from educational, social, recreational programs, health promotion, to cultural activities. **ISS *of* BC (Immigrant Services Society of British Columbia)** – Settlement services for newcomers to Canada. Provides a variety of programs and services in over 45 languages for immigrants and refugees to help them get settled, find careers and integrate into the community. E.g., Cross-cultural Peer Support Group for Immigrant and Refugee Women – Provides mental, physical and social support to marginalized immigrant and refugee women who are experiencing long-term and on-going challenges due to difficulties incurred during their integration process into Canadian society.

Community Services & Ethnic Community Supports	**City of Vancouver** – Works with diverse community sectors and organizations to support and integrate newcomers into local communities. E.g., Vancouver Immigration Partnership, Mentorship Program, Multicultural Advisory Committee, Restoring Chinatown. **Family Services of Greater Vancouver (Richmond)** – E.g., Community Kitchens and Language Orientation – A cooking program for low-income, disadvantaged, and recent immigrant community members with a focus on developing language skills and facilitating integration into Canadian society. **Mount Pleasant Family Centre Society** – Help with daily life and services for refugees. E.g., Parenting Program – For low-income and newcomer parents with the intent of strengthening parenting skills, reducing isolation and building community.

5.4 Future Research

Many questions regarding the relationship between immigrants and health or cancer risk in BC remain unanswered. As the immigrant population and ethnic diversity continues to grow in Canada and BC, more integrated, longitudinal research is needed to understand the complex pattern of health disparities and cancer risk, such as addressing the underlying mechanisms and why these disparities persist. Future research should aim to gain a better understanding of the specific factors at play (e.g., measuring lifestyle behaviours, changes in acculturation over time) and the unique protective effect or barriers experienced by the immigrant population. Some literature suggests disparities between health in immigrants and native-born populations may be attributed to acculturation and lifestyle factors, but research examining the determinants of cancer among immigrant populations appears to be more limited compared to the general population. A number of studies have started to examine these questions (e.g., Ng et al., 2005; Pérez, 2002; Chen et al., 1996a), yet the factors identified to date do not appear to fully account for the observed differences between immigrants and non-immigrants. Although evidence of the healthy immigrant effect exists for cancer in Canada, the effect is not equivalent for all immigrant populations. There is substantial heterogeneity within and between immigrant subgroups, and the fact that some immigrant sub-groups of certain ethnic origins experience a higher risk of certain cancers highlights the importance of ethnic/origin-specific research at smaller regional levels and the need for further indepth research examining the complex interactions of genetic predisposition, changing environmental exposures and lifestyle behaviours among immigrants. Further investigation on the determinants of immigrant health, particularly around protective effects and the influences of ethnic identity, social supports, resiliency, and factors associated with lower rates of specific cancers or risk factors will also be important in future work.

In Canada, current cancer registries and clinical data do not capture essential demographic information regarding ethnicity, country of birth, generational status, or immigration, thus presenting a gap in Canadian sources of data and a challenge for research seeking to understand the distribution of cancer across populations and sub-groups. Cancer registries play a vital role in disease surveillance and this is an important tool for appropriate planning and evaluation of both local and national cancer control strategies. There is a need for studies investigating generational status in Canada, as there are currently very few (Balzi et al., 1995). Illuminating studies in this area have been reported based primarily on United States data, facilitated by the inclusion of such data in their databases.

Research examining use of healthcare and cancer control services such as screening are an informative area of work to inform policy and healthcare changes. The literature suggests initially lower rates of physician contact, hospitalization, and reports of unmet needs among recent immigrants relative to Canadian-born populations, yet rates seem to increase over time and converge toward those in the general population (McDonald & Kennedy, 2004; Newbold, 2009; Setia et al., 2011). However, differences in knowledge, access to, or use of cancer screening services may persist among immigrant populations in Canada. A recent report by the Canadian Partnership Against Cancer suggests that although rates of cancer screening for breast, cervical and colorectal cancers are lowest among recent immigrants, rates seem to remain slightly lower among long-term immigrants compared with Canadian-born populations (Canadian Partnership Against Cancer, 2014).

5.5 Conclusion

Understanding the health and cancer risk of immigrants is important, as Canada is a major immigrant-receiving country and immigrants represent a large proportion of the BC population. Immigrants move from a country and environmental setting with one set of health risks, including behaviours, exposures, socioeconomic factors and constraints, to a new environment that may include very different risks. Immigrants have unique health experiences and health care needs upon arrival that change over time with duration of residence, indicating this is a population deserving attention as it experiences vulnerabilities to certain types of cancer. Specific cancer risk varies by immigrant country of origin, age at the time of immigration, and length of time in the new country. The influential role of immigrants' birthplace and age at arrival on determining trends in cancer risk highlights the possible role and interaction between genetic predisposition for some cancer types, exposure to changing environmental and lifestyle factors, and acculturative influences. Continued research in this area, and its translation into practice and policy, offer the promise of providing insight into both how to reduce cancer risk and meeting the needs of a priority population.

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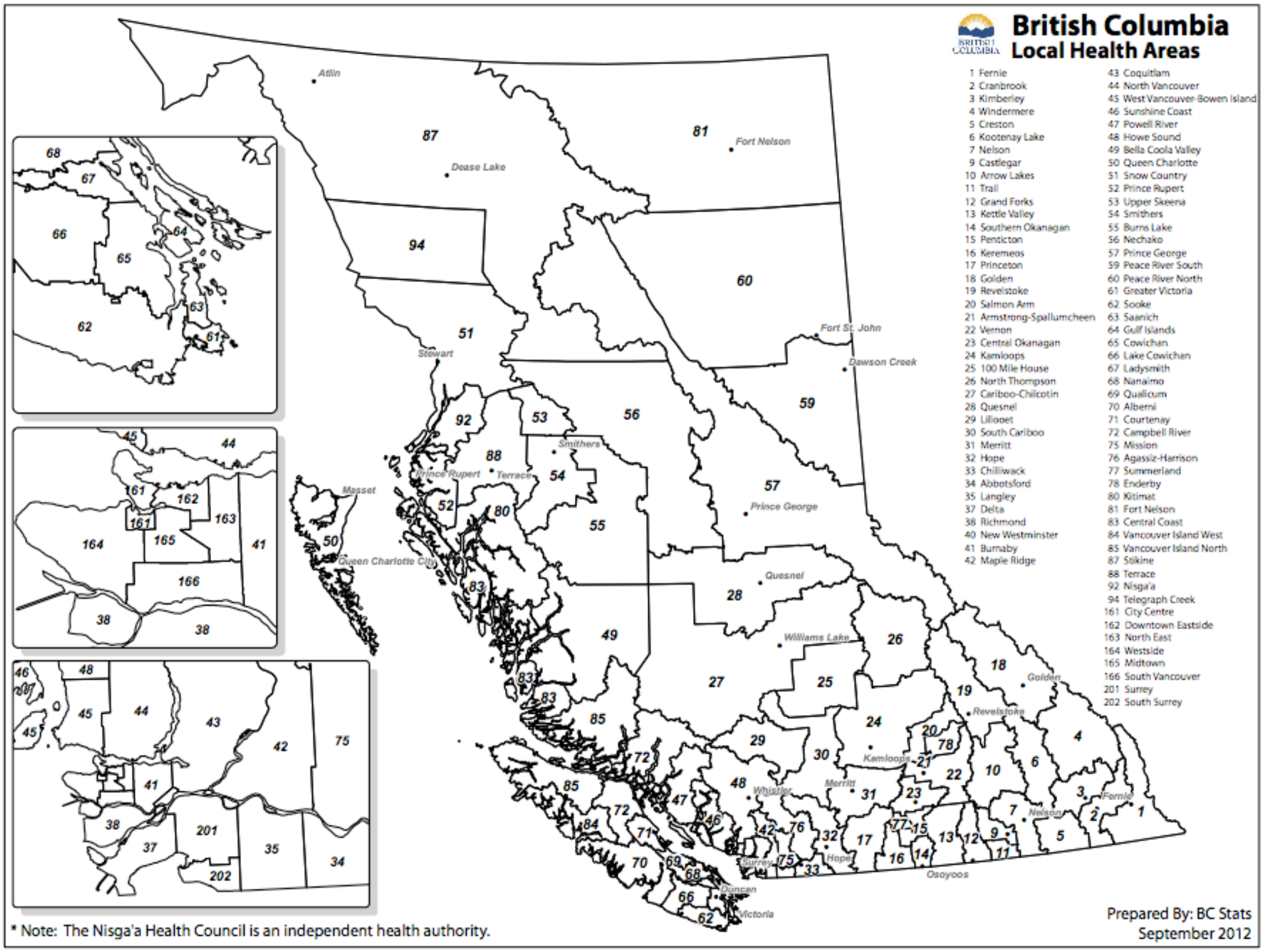
Appendices

Appendix A

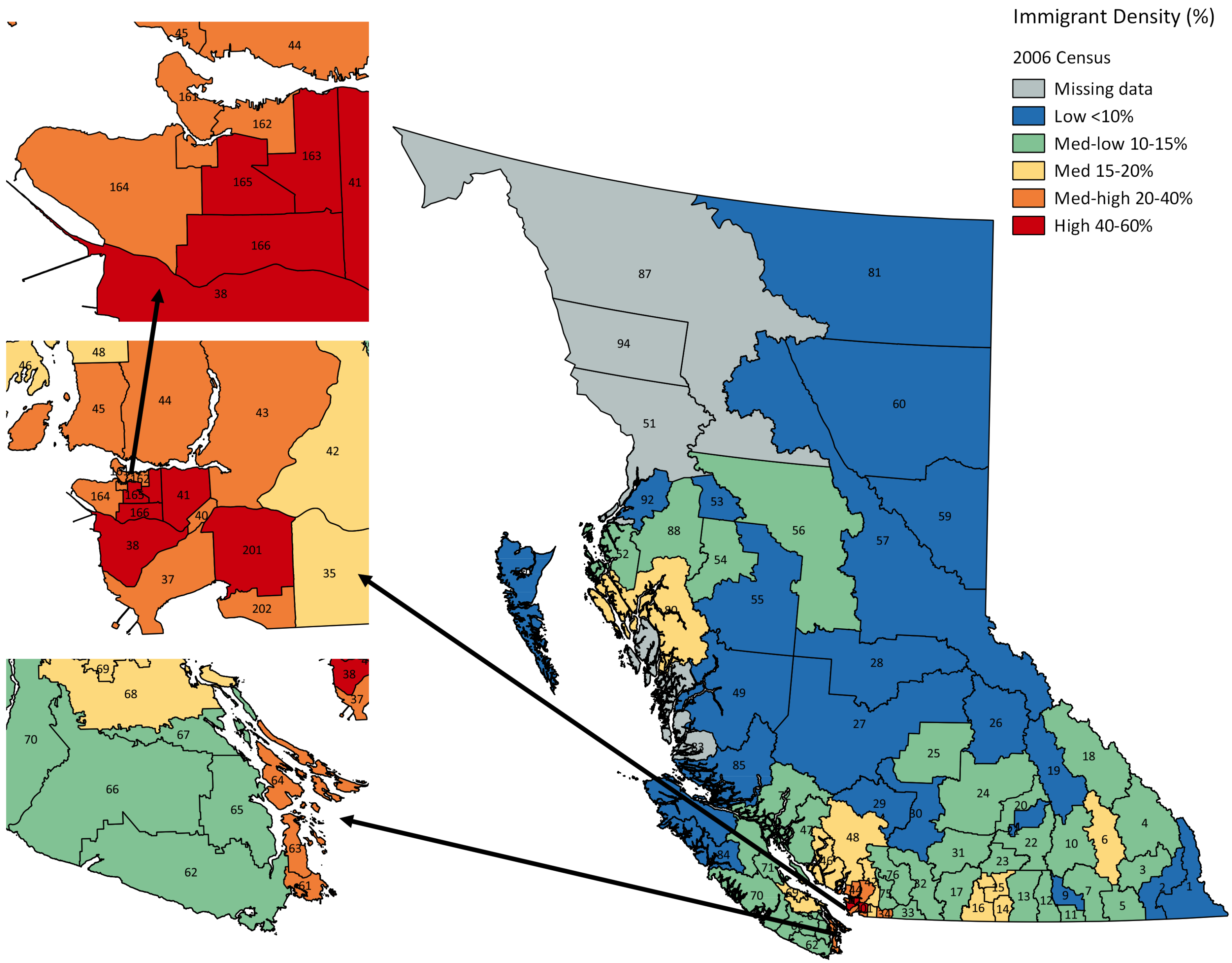
A.1 Local Health Areas (LHA) in BC

1	Fernie	25	100 Mile House	50	Queen Charlotte	76	Agassiz-Harrison
2	Cranbrook	26	North Thompson	51	Snow Country	77	Summerland
3	Kimberley	27	Cariboo-Chilcotin	52	Prince Rupert	78	Enderby
4	Windermere	28	Quesnel	53	Upper Skeena	80	Kitimat
5	Creston	29	Lillooet	54	Smithers	81	Fort Nelson
6	Kootenay Lake	30	South Cariboo	55	Burns Lake	83	Central Coast
7	Nelson	31	Merritt	56	Nechako	84	Vancouver Isl West
9	Castlegar	32	Hope	57	Prince George	85	Vancouver Isl North
10	Arrow Lakes	33	Chilliwack	59	Peace River South	87	Stikine
11	Trail	34	Abbotsford	60	Peace River North	88	Terrace
12	Grand Forks	35	Langley	61	Greater Victoria	92	Nisga'a
13	Kettle Valley	37	Delta	62	Sooke	94	Telegraph Creek
14	Southern Okanagan	38	Richmond	63	Saanich	161	Vancouver-City Centre
15	Penticton	40	New Westminster	64	Gulf Islands	162	Vancouver-Downtown Eastside
16	Keremeos	41	Burnaby	65	Cowichan	163	Vancouver-Northeast
17	Princeton	42	Maple Ridge	66	Lake Cowichan	164	Vancouver-Westside
18	Golden	43	Coquitlam	67	Ladysmith	165	Vancouver-Midtown
19	Revelstoke	44	North Vancouver	68	Nanaimo	166	Vancouver-South
20	Salmon Arm	45	West Van-Bowen Isl	69	Qualicum	201	Surrey
21	Armstrong-Spallumcheen	46	Sunshine Coast	70	Alberni	202	South Surrey/White Rock
22	Vernon	47	Powell River	71	Courtenay		
23	Central Okanagan	48	Howe Sound	72	Campbell River		
24	Kamloops	49	Bella Coola Valley	75	Mission		

A.2 Map of Local Health Areas (LHA) in BC



A.3 Map of immigrant density by Local Health Area (LHA) in BC



A.4 Population description of Local Health Areas (LHA)

LHA				% Immigrants by Time Since Immigration			% Immigrants by Age (years) at Immigration					% Immigrants by Birthplace		Socio-demographics		
		Total Population	Immigrant Population	All	Recent	Established	< 5	5-14	15-24	25-44	> 45	Europe	Asia	Income Quintile	% Educ (≥ BA)	% Visible Minority
1	Fernie	13985	1175	8.4	0.3	8.1	14.5	20.9	30.3	30.3	3.8	66	13.2	3	8.2	2.5
2	Cranbrook	23980	2105	8.8	0.6	8.2	14.3	18.3	24.9	39.2	3.3	72.2	4.5	2	8.9	1.4
3	Kimberley	7830	865	11.1	0.8	10.3	15.0	9.2	23.7	44.5	7.5	75.1	2.9	1	11.9	1.2
4	Windermere	9095	1070	11.8	0.6	11.2	8.8	12.6	27	47.4	3.3	73.4	2.3	4	13.4	1.8
5	Creston	11685	1520	13	0.5	12.5	8.9	15.5	24	44.4	7.2	69.7	3.0	1	8	1.3
6	Kootenay Lake	3590	590	16.4	0.7	15.7	6.8	13.6	29.7	43.2	6.8	58.5	1.7	1	13.7	1.3
7	Nelson	23300	2650	11.4	1.0	10.4	15.7	14.9	27.5	36.8	5.1	61.9	4.5	1	17	2.4
9	Castlegar	12250	1085	8.9	0.5	8.4	12.4	18.8	25.2	40.4	2.8	62.2	10.6	2	10.1	2.1
10	Arrow Lakes	4535	610	13.5	1.3	12.2	4.1	17.2	27.9	43.4	7.4	68.9	3.3	1	12.8	2.2
11	Trail	18305	2050	11.2	0.6	10.6	15.3	21.2	26.8	33.6	2.7	69.3	11.2	2	11.5	2.7
12	Grand Forks	8535	985	11.5	0.3	11.2	11.2	20.4	33.2	27.6	7.7	68.0	5.1	1	9.6	2.3
13	Kettle Valley	3460	370	10.7	0.9	9.8	9.3	17.3	12	50.7	9.3	60.8	8.1	1	7.8	5.3
14	Southern Okanagan	18315	3595	19.6	1.4	18.2	6.3	15.3	28.1	39.6	10.9	63.1	26.3	1	8.6	8.3
15	Penticton	39395	6460	16.4	0.7	15.7	9.0	15.5	26.5	40.2	8.8	66.1	17.2	1	10.8	5.2
16	Keremeos	4885	750	15.4	1.9	13.5	7.3	14.0	28.7	40.0	10.0	46.0	32.0	1	6	9.6
17	Princeton	4845	560	11.6	0	11.6	9.7	24.8	23	36.3	4.4	72.3	3.6	1	7	1
18	Golden	6870	945	13.7	1.7	12	10.1	17.5	26.5	38.1	7.4	57.7	16.9	1	10.1	5.9
19	Revelstoke	7790	740	9.5	1.2	8.3	14.9	23.0	23.0	33.1	5.4	81.1	4.1	1	10.5	1.8
20	Salmon Arm	31635	3370	10.7	0.9	9.8	12.3	21.2	25.4	34.6	6.5	73.6	5.9	1	9.7	1.1
21	Armstrong-Spallumcheen	9040	775	8.6	0.9	7.7	18.7	21.9	21.9	32.3	4.5	68.4	12.3	1	7.7	1.9
22	Vernon	59845	6955	11.6	1	10.6	11.2	19.7	28.0	33.9	7.3	65.3	15.8	1	11.9	3.6
23	Central Okanagan	160475	23720	14.8	1.4	13.4	10.5	19.2	26	37.2	7.1	69	14.0	3	12.6	5.2
24	Kamloops	101675	10670	10.5	0.7	9.8	12.8	20.0	25.7	35.5	6	60	20.4	2	11.4	5.3
25	100 Mile House	14040	1700	12.1	0.6	11.5	15.5	18.5	24.0	32.3	9.4	72.9	2.1	1	7.5	1.1
26	North Thompson	4120	395	9.6	1.1	8.5	15.2	10.1	21.5	44.3	6.3	65.8	6.3	1	8.5	2.1
27	Cariboo - Chilcotin	25405	2500	9.8	0.4	9.4	10.6	16.2	30.2	35.8	6.8	51.2	22.0	2	8.9	4.5
28	Quesnel	22385	2030	9.1	0.5	8.6	11.8	20.0	31.5	34.0	3.0	51.7	22.7	3	7.7	4.6
29	Lillooet	4220	305	7.2	0	7.2	9.7	29.0	21	33.9	4.8	54.1	0.0	1	9.0	1.3
30	South Cariboo	6950	565	8.1	0.1	8.0	8.0	23.0	32.7	31.0	6.2	56.6	12.4	1	6.8	2.2
31	Merritt	10865	1145	10.5	0.8	9.7	10.4	17.0	38.7	26.1	7.4	39.7	41.5	1	8.8	7.8

32	Hope	7915	1060	13.4	0.5	12.9	7.6	24.6	24.2	36.5	7.6	72.2	14.2	1	9.4	5.3
33	Chilliwack	76415	10580	13.8	1.0	12.8	14.9	21.6	24.1	35.3	4.1	67.9	12.4	2	8.9	4.3
34	Abbotsford	122800	32000	26.1	4.3	21.8	7.5	15.7	30.8	31.4	14.6	28.1	56.4	3	12.1	26.2
35	Langley	116900	20125	17.2	2.6	14.6	13.3	21.3	22.6	36.3	6.5	49.9	30.6	5	13.5	10.1
37	Delta	96750	27120	28	3.8	24.2	8.5	17.3	25.6	36.9	11.7	32.8	50.5	5	18.8	26.9
38	Richmond	173570	99660	57.4	10.8	46.6	6.6	17.7	17.8	41.6	16.3	10.9	81.6	4	26.2	65.1
40	New Westminster	57850	18360	31.7	7.3	24.4	7.6	16.0	24.0	42.9	9.4	32.4	50.7	2	21.6	29.6
41	Burnaby	200855	102030	50.8	10.8	40.0	7.0	17.7	20.3	41.8	13.2	18.8	69.6	3	26.3	55.4
42	Maple Ridge	84030	14995	17.8	2.2	15.6	11.2	19.9	22.9	39.5	6.5	52.9	28.9	4	11.0	11.5
43	Coquitlam	195745	67985	34.7	6.4	28.3	8.2	20.5	18.2	41.8	11.3	26.6	60.3	5	21.7	32.9
44	North Vancouver	128820	42705	33.2	5.9	27.3	8.1	18.4	19.9	43.7	9.8	37.1	44.1	5	29.8	23.7
45	West Vancouver-Bowen Isl	48895	17480	35.7	5.6	30.1	6.9	15.9	21.9	41.8	13.5	40.8	41.6	5	39.4	21.7
46	Sunshine Coast	27510	4790	17.4	1.0	16.4	9.7	16.6	24.7	40.6	8.4	67.6	8.6	1	16.4	4.6
47	Powell River	18970	2805	14.8	1.2	13.6	10.3	13.9	29.9	42.4	3.2	71.3	9.1	1	11.5	2.8
48	Howe Sound	30915	5335	17.3	3.4	13.9	9.5	17.9	21.6	42.3	8.8	45.2	33.0	4	18.3	10.5
49	Bella Coola Valley	2885	205	7.1	0	7.1	9.8	19.5	36.6	29.3	4.9	46.3	0.0	1	9.1	1
50	Queen Charlotte	4795	390	8.1	0.8	7.3	19.5	20.8	18.2	35.1	6.5	47.4	14.1	1	12.9	1.9
52	Prince Rupert	14220	1680	11.8	0.6	11.2	8.9	14.9	31.0	38.4	7.1	46.4	43.5	1	10.1	9.9
53	Upper Skeena	5320	285	5.4	0.2	5.2	5.3	24.6	29.8	36.8	3.5	31.6	14.0	1	6.3	1
54	Smithers	15785	1730	11.0	0.8	10.2	12.2	20.0	24.9	36.2	6.7	59.0	14.5	3	11.0	3.6
55	Burns Lake	7620	750	9.8	0.4	9.4	12.7	16.7	22.7	39.3	8.0	49.3	4.0	1	7.7	0.9
56	Nechako	14715	1505	10.2	0.2	10.0	15.0	22.9	19.6	36.9	5.3	41.9	14.0	3	7.6	3.5
57	Prince George	92045	8650	9.4	0.6	8.8	11.2	21.8	27	33.2	6.7	55.1	23.0	4	11.6	5.1
59	Peace River South	25810	1860	7.2	0.8	6.4	10.2	25.2	21.2	36.5	7.0	57.0	15.1	4	7.5	2.0
60	Peace River North	31810	2285	7.2	1.2	6.0	15.3	22.5	25.2	30.4	6.6	54.7	11.8	5	8.4	2.2
61	Greater Victoria	206545	42395	20.5	2.3	18.2	10.1	16	23.3	42.2	8.4	50.3	29.0	2	26.3	12.8
62	Sooke	58190	7235	12.4	0.9	11.5	12.4	22.7	23.0	37.7	4.2	64.2	14.6	4	13.6	5
63	Saanich	60830	12405	20.4	1.3	19.1	9.2	15.6	26.6	40.7	7.9	65.1	15.9	5	23.5	7.5
64	Gulf Islands	14490	3500	24.2	1.6	22.6	10.6	14.6	24.0	42.9	8.0	69.3	6.6	2	26.5	2.8
65	Cowichan	53205	7320	13.8	0.8	13	11.4	17.1	27.5	36.5	7.5	69	13.4	3	12.9	4.6
66	Lake Cowichan	6075	680	11.2	0.4	10.8	10.2	16.1	25.5	37.2	9.5	67.6	19.9	1	5.5	5.5
67	Ladysmith	17195	2205	12.8	0.5	12.3	11.3	16.6	27.2	38.3	6.1	74.4	10.0	1	12.1	2.3
68	Nanaimo	95150	14795	15.5	1.4	14.1	9.4	17.1	24.3	41.7	7.4	60.3	21.8	1	14.6	7.1
69	Qualicum	42360	8190	19.3	1.3	18.0	8.5	16.0	23.8	45.8	5.9	79.9	6.0	1	13.6	2.8
70	Alberni	30435	3285	10.8	0.2	10.6	8.8	17.8	31.7	36.4	5.2	67.6	16.9	1	8.0	4.1
71	Courtenay	59140	8080	13.7	0.8	12.9	11.7	17.8	26.2	38.5	5.8	67.3	10.6	2	14.3	3.0

72	Campbell River	39350	4300	10.9	0.7	10.2	12.0	18.7	25.1	38.5	5.6	64.2	12.1	1	9.9	3.2
75	Mission	38560	5785	15.0	1.9	13.1	10.0	19.6	26.4	34.6	9.3	49.8	31.7	3	9.2	9.9
76	Agassiz - Harrison	7940	1190	15.0	0.4	14.6	11.0	17.7	24.5	40.9	6.8	71.8	11.3	1	8.5	2.7
77	Summerland	11125	1795	16.1	1.2	14.9	12.2	17.5	26.1	36.7	6.9	70.2	12.3	2	13.3	3.4
78	Enderby	7330	660	9.0	0.5	8.5	11.5	20.6	19.1	43.5	4.6	67.4	3.8	1	7.7	1.8
80	Kitimat	10035	1980	19.7	0.7	19	7.6	16.2	34.6	37.6	3.8	73.5	16.4	4	7.5	6
81	Fort Nelson	6220	295	4.7	1.0	3.7	13.6	11.9	30.5	35.6	10.2	35.6	45.8	5	7.1	5
84	Vancouver Isl West	2275	185	8.1	0.4	7.7	18.9	10.8	48.6	18.9	0	75.7	0	1	6.7	0
85	Vancouver Isl North	11905	1050	8.8	0.6	8.2	9.6	18.7	23.0	38.3	10.0	57.6	10.0	1	9.3	3.1
88	Terrace	19605	2120	10.8	0.9	9.9	14.4	23.6	24.1	33.0	5.2	60.6	20.3	1	9.6	5.1
92	Nisga'a	1925	25	1.3	0	1.3	50.0	0	50.0	50.0	0	0	40.0	1	7.9	0.5
161	Vancouver--City Centre	101935	35615	34.9	7.4	27.5	6.5	16.4	19.9	45.7	11.5	35.4	46.7	2	42.8	30.6
162	Vancouver--Downtown Eastside	51960	18785	36.2	5.5	30.7	6.9	14.7	19.0	38.6	20.7	21.9	66.2	1	23.5	38.2
163	Vancouver--North East	97215	54025	55.6	7.4	48.2	5.7	14.8	22.9	42.4	14.2	11.9	80.6	1	18.9	70.8
164	Vancouver--West Side	124590	44865	36.0	7.6	28.4	8.2	20.5	17.6	44.2	9.6	27.3	57.4	5	49.5	32.4
165	Vancouver--Midtown	81035	36645	45.2	6.7	38.5	6.5	14.6	20.3	44.9	13.6	13.8	75.2	2	29.6	53.5
166	Vancouver--South	126950	76180	60.0	10.4	49.6	5.7	16.5	22	41.1	14.8	9.7	82.5	3	25.4	74.3
201	Surrey	334430	136290	40.8	8.2	32.6	6.7	14.7	28.2	35.3	15.1	14.8	70.9	4	14.3	52.1
202	South Surrey/White Rock	76435	18395	24.1	3.1	21.0	9.2	18.6	20.8	42.6	8.8	54.9	26.9	5	21.8	11.1
British Columbia		4074380	1119215	27.5	4.4	23.1	8.0	17.3	22.8	40.1	11.8	54.2	31.2	-	19.3	24.8

Appendix B

B.1 List of countries included in European country of origin variables

European origins	
Western European	**Northern European**
Austria	Ireland
Belgium	Scandinavia
France	Denmark
Germany	Finland
Liechtenstein	Iceland
Luxembourg	Norway
Monaco	Sweden
Netherlands	United Kingdom
Switzerland	
Eastern European	**Southern European**
Bulgaria	Albania
Czech and Slovak Federal Republic, former	Andorra
Czech Republic	Gibraltar
Slovakia	Greece
Czechoslovakia, n.o.s.	Holy See (Vatican City)
Hungary	Italy
Poland	Malta
Romania	Portugal
USSR, former (European component)	San Marino
Baltic Republics, former Soviet	Spain
Estonia	Yugoslavia, former
Latvia	Bosnia and Herzegovina
Lithuania	Croatia
Eastern Europe Republics, former Soviet	Macedonia
Belarus	Slovenia
Moldova, Republic of	Serbia and Montenegro
Russian Federation	Yugoslavia, n.o.s.
Ukraine	
USSR, n.o.s.	

B.2 List of countries included in Asian country of origin variables

Asian origins	
West Central Asia and the Middle East	**South Asian**
Afghanistan	Bangladesh
Cyprus	Bhutan
Iran	India
Middle East	Maldives
Bahrain	Nepal
Iraq	Pakistan
Israel	Sri Lanka
Jordan	**Southeast Asian**
Kuwait	Bangladeshi
Lebanon	Brunei Darussalam
Oman	Cambodia
Palestine/West Bank/Gaza Strip	East Timor (formerly part of Indonesia)
Qatar	Indonesia
Saudi Arabia	Laos
Syria	Malaysia
United Arab Emirates	Myanmar (formerly known as Burma)
Yemen	Philippines
Turkey	Singapore
USSR, former (Asian component)	Thailand
Central Asian Republics, former Soviet	Vietnam
Kazakhstan	**East Asian**
Kyrgyzstan	China, People's Republic of (incl. Hong Kong)
Tajikistan	Macau
Turkmenistan	Japan
Uzbekistan	Korea, North
Transcaucasian Republics, former Soviet	Korea, South
Armenia	Mongolia
Azerbaijan	Taiwan
Georgia	