CHRONIC DISEASE DEVELOPMENT AND MULTIMORBIDITY AMONG IMMIGRANTS AND REFUGEES IN ONTARIO

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GENERAL ABSTRACT

Chronic diseases such as cancer, diabetes, cardiovascular and respiratory diseases are a global concern. In recent decades, Canada has also experienced a major increase in immigration. Yet, a detailed profile of chronic disease and multimorbidity risk patterns across different immigrant populations has been lacking in Canada. The purpose of this dissertation is to identify knowledge gaps in the scientific literature on the development of chronic conditions and multimorbidity across immigrant populations in Ontario, using population-based immigrant and health data housed at ICES.

The principal findings of this dissertation indicate that:

1. The risk of developing a chronic condition and multimorbidity was complex and varied by immigrants' visa category and world region origin since:
    a. Refugees had the highest risk of developing a chronic condition and multimorbidity (two or more co-occurring chronic conditions) compared to long-term Ontario residents.
    b. There were differences in the risk of developing a chronic condition and multimorbidity by world regions of origin, when examined across different immigrant categories.
2. Hypertension and diabetes, and in combination with Chronic Obstructive Pulmonary Disease were the leading multimorbidity dyad and triad groups for all immigrant categories and long-term residents of Ontario.
3. The risk of developing a chronic condition increased among immigrants in more recent landing cohorts. The risk was highest among more recent refugees, and lower for family and economic class immigrants, when compared to long-term Ontario residents.

These findings provide evidence to inform public health policy and planning by highlighting the complexity and heterogeneity of health outcomes across immigrant populations. Knowledge generated from this work will inform policies and evidence-based decision-making aimed to address the threat of chronic diseases and reduce health disparities.

PREFACE

The research presented in this thesis was approved by the University of Ottawa Health Science and Science Research and Ethics Board (uOttawa ethics file #: H02-17-20).

This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health and Ministry of Long-Term Care (MOH and MLTC). Part of this material are based on data and information compiled and provided by: MOH and MLTC, the Canadian Institute for Health Information (CIHI) and Immigration, Refugees and Citizenship Canada (IRRC). The analyses, conclusions, opinions, and statements expressed herein are solely those of the author and do not reflect those of the funding or data sources; no endorsement is intended or should be inferred.

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"… One indeed is a man who, today, dedicateth himself to the service of the entire human race. The Great Being saith: Blessed and happy is he that ariseth to promote the best interests of the peoples and kindreds of the earth…It is not for him to pride himself who loveth his own country, but rather for him who loveth the whole world. The earth is but one country, and mankind its citizens." – Baha'u'llah

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As a result of my family's sacrifice, I often reflect on the countless opportunities this great nation has presented to my entire family who immigrated here over 30 years ago as government-sponsored refugees due to the ongoing persecution of the Baha'is in Iran. I would not be here today, had Canada not bestowed its generosity and hospitality upon my family through its humanitarian efforts and open-minded public policies. As a result, I had the great bounty to be born and raised in a country that prospers in its diversity, tolerance and acceptance of all people, cultures, and faiths and to have access to higher education and many other opportunities in this great country.

CONTRIBUTIONS

I was responsible for preparing this doctoral dissertation, including the development of the thesis objectives, conducting the literature review, conceptualizing the methodologies, performing all statistical analyses at ICES uOttawa, interpretation of findings and writing each chapter of this thesis.

Several key individuals contributed to the completion of this thesis. Dr. Simone Dahrouge and Dr. William Hogg were my thesis co-supervisors and provided feedback on the research objectives, study design, analysis, and interpretation of findings, including feedback on the draft chapters of this thesis.

Thesis committee members Dr. Richard Glazier and Dr. Doug Manuel provided feedback on the research objectives, study design, analysis, and interpretation of findings including feedback on every thesis chapter.

Dr. Meltem Tuna and Coralie Wang extracted and prepared the linked datasets at ICES uOttawa.

I would also like to acknowledge Dr. Astrid Guttmann and Dr. Sani Yaya for kindly accepting to act as external reviewers of this doctoral dissertation and taking the time to read and provide valuable comments and suggestions.

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CHAPTER 1 - INTRODUCTION

1.1 THESIS OVERVIEW

The purpose of this thesis is to identify and address some of the knowledge gaps in the scientific literature on the development of chronic conditions and multimorbidity across immigrant populations. It offers the unique opportunity to utilize population-based immigrant and health data housed at ICES.

ICES is an independent, non-profit research institute whose legal status under Ontario's health information privacy law allows it to collect and analyze health care and demographic data, without consent, for health system evaluation and improvement.[1]

The goal of this work is to generate knowledge that will inform evidence-based decision-making (e.g., financing, resource allocation and healthcare planning) to reduce the threat of chronic diseases and manage them with shared common strategies.

To this end, this dissertation addresses three distinct, interconnective objectives:

- Objective 1: Chronic condition outcomes among different immigrant categories
- Objective 2: Rates and patterns of multimorbidity across immigrant categories
- Objective 3: Cohort effects for chronic condition outcomes among different immigrant populations

[1] In 2018, the institute formerly known as the Institute for Clinical Evaluative Sciences formally adopted the initialism ICES as its official name. This change acknowledges the growth and evolution of the organization's research since its inception in 1992, while retaining the familiarity of the former acronym within the scientific community and beyond.

This thesis is organized in a manuscript-based format adhering to the University of Ottawa dissertation guidelines. Chapter 1 (INTRODUCTION) lays the background context on the importance of chronic disease, multimorbidity and immigration. The conceptual framework that informed the context of this dissertation is presented and discussed, including its relevance and applicability to immigrant health. A literature review was then conducted to examine the risks of chronic disease across the general and immigrant populations, the health status of immigrants, and disparities between immigrant sub-populations. This helped identify knowledge gaps in the scientific literature, develop the thesis objectives and research questions, the impact and rationale for this dissertation, each described further in Chapter 1.

The thesis objectives have been divided into three manuscript-based chapters (CHAPTERS 2 to 4), each addressing distinct research questions (described below under thesis objectives and research questions). Chapter 2 is the first manuscript of this dissertation, titled: "*Risk of Developing a Chronic Condition among Immigrants and Long-term Residents of Ontario between 1995-2016*". Chapter 3 is the second manuscript of this dissertation titled: "*Risk of Developing Multimorbidity among Immigrants and Long-term Residents of Ontario from 1995-2016 in Ontario, Canada*". Chapter 4 is the third manuscript titled: "*Cohort and Migration Patterns: Comparing Trends in Chronic Condition Outcomes among Immigrant Populations in Canada*".

Chapter 5 (DISCUSSION) highlights the main findings of this dissertation, the research implications for policy and program planning, future directions for research, the strengths and limitations, and concluding remarks.

1.2 **BACKGROUND**

1.2.1 Importance of chronic diseases

Chronic diseases such as cancer, diabetes, cardiovascular and respiratory diseases are a global concern, with alarming prevalence and incidence rates in both the developed and developing

world (WHO, 2015; PHAC, 2016). They are among the most serious health problems that incur costs to governments, communities, and individuals (Hospedales & Jané-Llopis, 2011). Deaths from chronic diseases are often avoidable (Roberts et al., 2015; WHO, 2015; PHAC, 2016). In 2012, 68% of deaths worldwide resulted from heart disease, cancer, stroke, diabetes, and respiratory illnesses. In Canada, one in three individuals live with at least one major chronic disease (Roberts et al., 2015; Ronksley et al., 2014), that has resulted in 27% premature deaths of individuals under the age of 70 in 2012 (WHO, 2015).

1.2.2 Multimorbidity

Multimorbidity is defined as having two or more chronic conditions (Boyd and Fortin, 2010). It is often used as a general measure of overall health status (Diaz et al., 2015). Multimorbidity is an important public health issue and has been associated with greater risk of adverse health outcomes, more frequent hospitalizations, greater healthcare needs, and premature death (Rosella et al., 2014; Lofters et al., 2014; Pefoyo et al., 2015; Roberts et al., 2015; Agborsangaya et al., 2013; Boyd and Fortin, 2010).

1.2.3 Immigrants and Refugees in Canada

In recent decades, Canada has experienced a major increase in immigration. This trend is especially true for the province of Ontario, which is home to the largest population of immigrants in Canada (Immigration, Refugees and Citizenship Canada, 2018). Statistics Canada estimates that by 2031 the proportion of foreign-born Canadians will increase up to 28% (Cymbal & Bujnowski, 2010; Statistics Canada, 2006; Beiser, 2005). On average, Canada accepts around 250, 000 immigrants

annually. This includes 20,000 to 30,000 Convention Refugees [2]as part of its humanitarian commitment to the United Nations (Statistics Canada, 2019; Immigration, Refugees and Citizenship Canada, 2018; Rouhani, 2011; Cymbal & Bujnowski, 2010; Beiser, 2005).

The majority of immigrants entering Canada are classified as economic (i.e. those who immigrant with a business visa or bring in skills that will benefit the Canadian economy), families (immigrants who are sponsored as spouses, common-law partners or immediate family members such as dependent children or parents) and refugees (individuals recognized as United Nation Convention refugees prior to entering Canada in need of safety and protection) (Durbin et al., 2015; Immigration, Refugees and Citizenship Canada, 2018; Rouhani, 2011).

Upon entry to Canada, immigrants (family reunification and economic class immigrants) and Convention Refugees (government and private sponsored) are collectively referred to as *landed immigrants* with permanent residency status (Minister of Justice, 2019). Permanent residents must reside in Canada for a minimum of three years before applying for Canadian Citizenship. After receiving Citizenship, they are no longer referred to as permanent residents and are entitled to the same rights and liberties as other Canadians (Minister of Justice, 2019; Hou and Picot, 2019; Rouhani, 2011).

[2] An individual whose refugee claim was accepted by the United Nations High Commissioner of Refugees (UNHCR), who cannot return to their country of origin and who resettles in a foreign country (Immigration, Refugees and Citizenship Canada, 2013).

1.3 CONCEPTUAL FRAMEWORK

This thesis incorporates the Commission on the Social Determinants of Health model (CSDH), illustrated in figure 1.1 to help understand and conceptualize the factors affecting immigrant and refugee health.

1.3.1 The Commission on Social Determinants of Health Model

The CSDH model addresses the impact of inequities on health and well-being. The CSDH was established by the WHO to gather evidence on the social determinants of health, their impact, and what can be done to achieve global health equity (WHO, 2008). The final report was published in 2008 '*Closing the gap in a generation: Health equity through action on the social determinants of health* (WHO, 2008).

The CSDH describes the social determinants of health, and the multi-level relationships that form the context in which different populations experience health and well-being. This framework is built on several existing theoretical models to better understand the underlying processes that underpin health inequities (WHO, 2008).

The WHO report recommended that national governments adopt this framework to better understand and improve the health of populations by acting on these social determinants of health that range from daily living conditions to structural drivers of health inequities to inform policy and program development (WHO, 2008).

The CSDH model identifies and describes the factors that contribute towards the unequal distribution of health and well-being. The framework was developed by Solar & Irwin (2007) and guided the CSDH's work from 2005 to 2008. It identifies three elements that shape the structural and intermediary conditions that constitute the social determinants of health described below (WHO, 2008) and summarized in Figure 1.1:

- Socio-economic and political context

- Structural determinants and socioeconomic position
- Intermediary determinants

The CSDH model highlights the complex relationship between social determinants of health, structural causes of health inequities, and the health system and health outcomes from the macro context of policies, the socioeconomic context down to individual level health behaviours. It further emphasizes that interventions should also address the structural determinants that cause the systematic distribution of health determinants in society creating inequities (WHO, 2008).

The structural determinants impact the distribution of the social determinants of health in society and shape the conditions of daily life that individuals grow, live and work in (WHO, 2008). In this model, this is contextualized as one's social positioning (determined by their socio-economic positioning (i.e., education, occupation, and income], gender, and ethnicity) (WHO, 2008; Solar & Irwin, 2007).

The socio-political context and social hierarchy lay the foundation and shape the distribution of the intermediary social determinants of health in society (e.g., factors that encompass more proximal determinants of health), and experience differences in material circumstances, behaviours and lifestyle habits (WHO, 2008). Coupled with biological factors (e.g., genetics, sex), differences in exposure to these circumstances will impact the way these different groups will experience disease and health, and in turn how they access healthcare services (WHO, 2008).

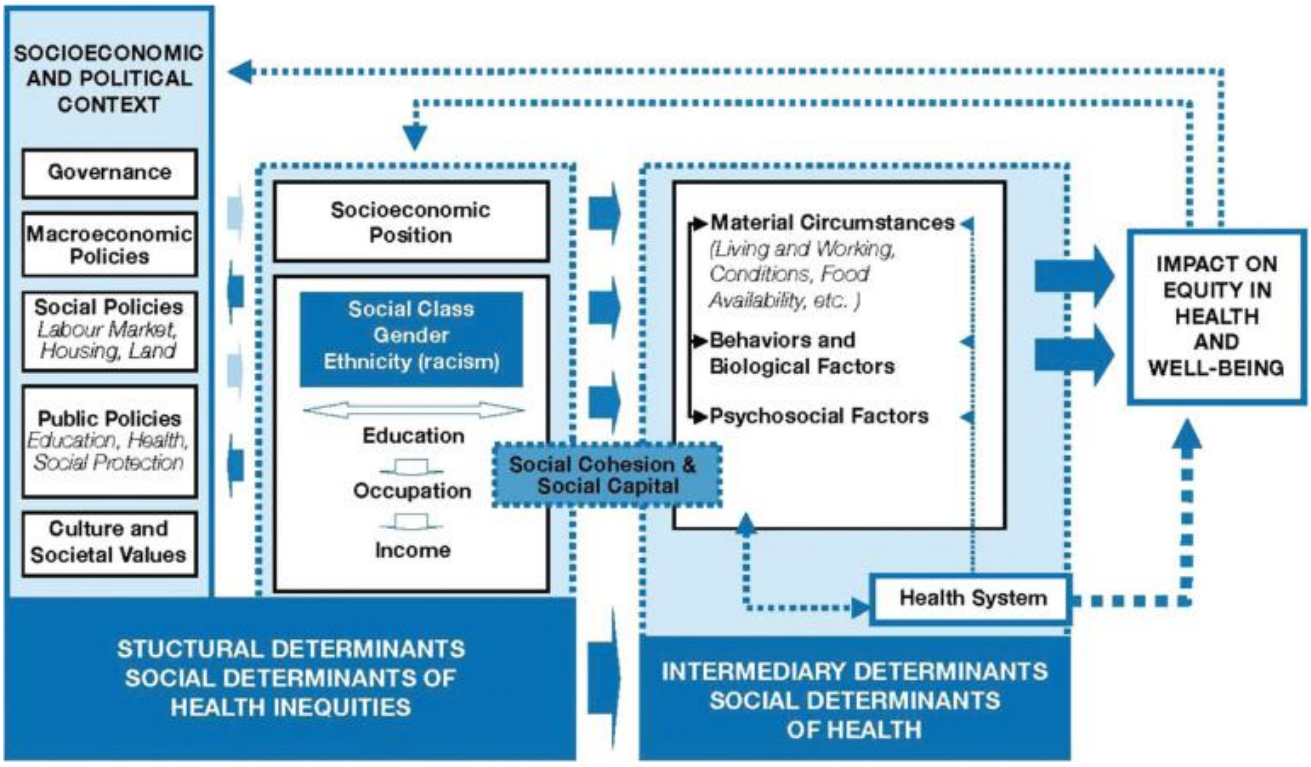
The way the healthcare system responds to health, wellness, and disease prevention in the population (e.g., accessibility, healthcare service utilization) will further contribute towards the distribution of health and disease in the population (WHO, 2008; Solar & Irwin, 2007).

The socio-economic and political context in Canada combined with socially ascribed gender roles, the economic/labour climate, discrimination, social supports, and networks work together to establish an individual's socio-economic position and related health outcomes in Canada

(Creatore, 2013; WHO, 2008). The CSDH model offers a comprehensive context on how these factors interact to determine health outcomes among immigrant populations in Canada.

For the purposes of this doctoral project, the CSDH framework will help us better understand the context of health and inequities in the immigrant population, inform our analytic approach, interpret findings, develop interventions, and provide recommendations aimed to reduce health inequities.

Figure 1.1 The World Health Organization's Commission on the Social Determinants of Health conceptual framework.



The components addressed in the CSDH model are relevant within the immigrant health context. Immigration influences both the structural and intermediary determinants of health and chronic disease outcomes, in the context of the pre- and post- migration experiences and exposures

(Creatore, 2013). Figure 1.2 illustrates the relationship of the multi-level factors identified in the CSDH model that impact the health and well-being of immigrant populations.

Governance structures and public policies – conceptualized in the CSDH model as the structural determinants (e.g., the Immigrant and Refugee Protection Act) influence the type and demographic of immigrants that are selected to migrate and settle in Canada. This in turn impacts the way they access and utilize social and health services that are made available to them post-settlement (such available services may also be subject to existing and trending policies and programs), and how these factors interact and impact health outcomes (Creatore, 2013).

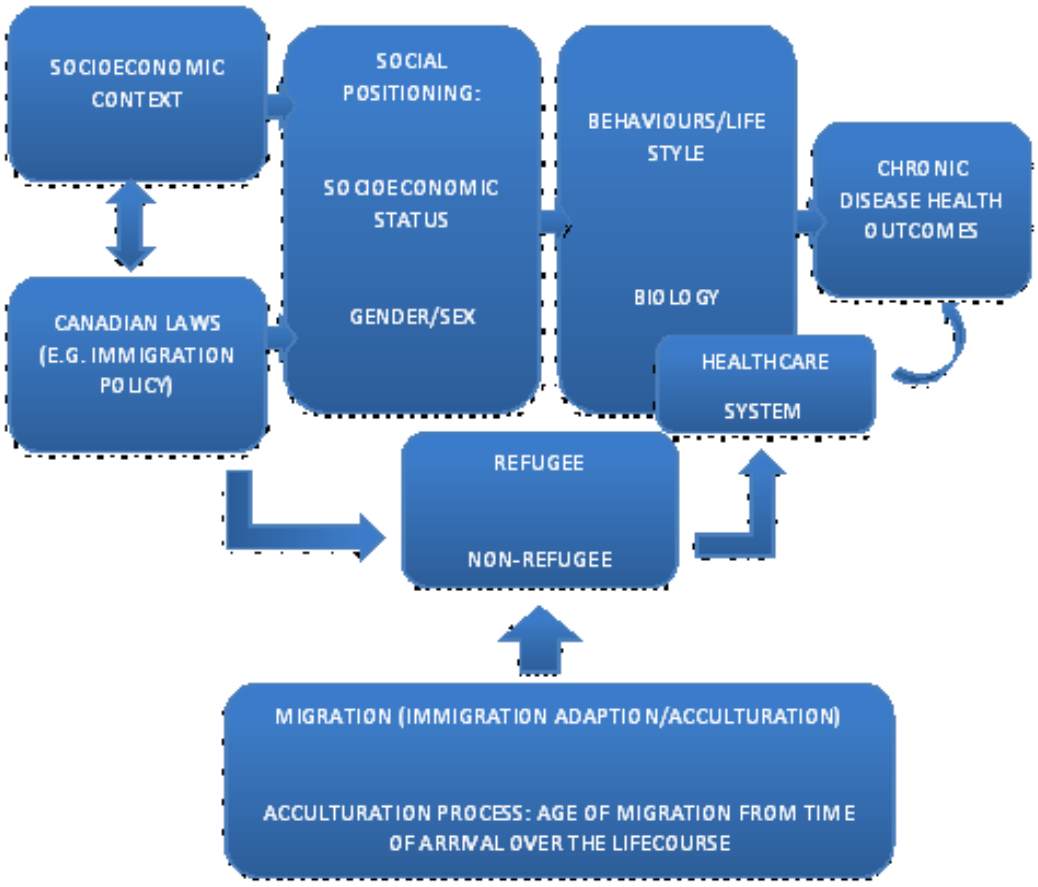
The socioeconomic and political environment, the social structure, and the distribution of power in an immigrants' host country, combined with their pre-migration experiences (e.g., reasons for their migration, if and any underlying health conditions and risk factors) will all impact their socio-economic position and health outcomes post-migration in Canada (Creatore, 2013; WHO, 2008).

Their socioeconomic position is further influenced by social class (e.g., income level, ability to obtain and secure employment, transfer of educational credentials and/or means to access post-secondary education post-migration), gender, and ethnicity (e.g., migration from high endemic world regions of origin, racial discrimination, and visible minority status post-migration) - factors that are known to impact social and health inequalities in Canada (PHAC, 2016).

This in turn affects material circumstances such as their living and working conditions, food security, and social capital all of which impact behavioral and psychosocial factors (WHO, 2008). Coupled with biological factors (e.g., genetic predisposition to disease and sex), differences in exposure to these material circumstances will impact the way immigrants and refugees will experience health and health inequities, and in turn how they access and utilize healthcare services

across their lifespan as they adopt health behaviours and acculturate over the years they live in Canada (PHAC, 2016; Creatore, 2013; WHO, 2008).

Figure 1.2 Modified representation of the CSDH model in the context of immigrant health in Canada



1.4 LITERATURE REVIEW

1.4.1 Chronic Disease and Multimorbidity in the General Population

Traditional Chronic Disease Risk Factors

Many factors that contribute to developing chronic diseases are overlapping and modifiable, such as lifestyle and delivery of healthcare services. Other factors are non-modifiable, such as advanced age, a family history of disease, genetics, and ethnicity (WHO, 2015; PHAC, 2015; PHAC 2012). Lifestyle factors, including unhealthy weight, smoking, low levels of physical activity, and poor diet are amongst those contributing to the burden of chronic diseases in Canada (WHO, 2015; PHAC, 2016).

Socioeconomic status is also an important determinant of health in Canada, as conceptualized in the CSDH framework. Lee, Chiu, Manuel, and colleagues (2009) examined trends in risk factors for cardiovascular disease in Canada, and the impact of socio-economic status on these risk factors using data from the National Population Health Survey (NPHS) and the Canadian Community Health Survey (CCHS). During the study period, hypertension, diabetes, and obesity increased for all or most income groups in Canada, but significantly more in the lowest income category (Lee et al., 2009).

The risk of developing a chronic condition is significantly higher when multiple lifestyle factors are present. For example, Alter and colleagues (2012) reported the likelihood of healthy obese individuals developing future diabetes and hypertension rose significantly when factors such as smoking, physical inactivity and/or psychosocial distress were present at baseline (Alter et al., 2012).

A study reported 32% of all hospital bed days between 2001 and 2012 in Ontario were linked with chronic disease risk factors (smoking, unhealthy alcohol consumption, poor diet, and physical inactivity) (Manuel et al., 2014). A 2016 report examined the ten-year impact of these four

health behaviour risk factors: attributing to 22% of health care costs. Physical inactivity and smoking contributed to the largest proportion of the burden (Manuel et al., 2016).

1.4.2 Stress and Health Outcomes

Stress is a risk factor in almost all mental and physical illnesses. It places a physiological demand on the body to which an individual must adapt, cope or adjust (Nevid & Rathus, 2003; APA, 2016). Intense or prolonged stress can impact all aspects of health and is important in the development of a wide range of diseases. The American Psychological Association (APA) defines two types of stress that manifest as acute or chronic (APA, 2016; APA, 2011). Acute stress is the most common type, stemming from recent pressures and anticipated demands for the future (APA, 2016; APA, 2011). Chronic stress is a long-term form of stress that stems from "*unending feelings of despair/hopelessness resulting from poverty, traumatic or early childhood experience*" (APA, 2016, p.1). Factors such as perceived discrimination, acculturative, environmental, and migration stress are known chronic stressors associated with diseases (Schneiderman, Ironson, & Siegel, 2005)Djuric et al., 2010, APA, 2016).

A recent systematic review examined the relationship between stress and subsequent mental and physical health outcomes using only longitudinal studies as an inclusion criterion (Garfin, Thompson, & Holman, 2018). The systematic review reported an association with poor general physical health, increased disability, higher risk for all-cause mortality, lower quality of life and significant psychological outcomes such as anxiety and depression (Garfin et al., 2018).

Stress alters physiological functioning and leads to disease through several pathways (Yaribeygi et al., 2017; APA, 2016; Djuric et al., 2010). It affects the body's tissues and impairs its ability to defend against any form of disease, higher cortisol levels in the body, elevated markers of biological aging, changes in growth hormones, and suppresses immune function (Mariotti, 2015). It

may prematurely age the immune system and increases the risk for virtually all health problems including age-related diseases (Yaribeygi et al., 2017; APA, 2016; Geronimus et al., 2010).

When an individual is exposed to repeated or chronic physical and emotional stress, an allostatic load is accumulated in the body and in turn reduces the body's generalized resistance to disease (Mariotti, 2015; Szanton, Gill, & Allen, 2005) . This is a mechanism that explains why the risk of most chronic conditions are heightened as a result of stress, and why it is considered a risk factor for a number of major chronic illnesses including cardiovascular disease, obesity, diabetes, depression, cognitive impairment, and inflammatory and autoimmune disorders (Cohen, Janicki-Deverts, & Miller, 2007; McGuire, Ahearn, & Doering, 2015). Stress also has direct associations with injuries, and suicides as well as indirect associations with cancer and upper respiratory illnesses (APA, 2016; Djuric et al., 2010)

Current gaps in the scientific literature include longitudinally examining the processes that manifest into stress, as a determinant across different populations, on a wide range of health outcomes at the population-level.

1.4.3 Multimorbidity in Canada

There is growing recognition that chronic diseases do not develop in isolation, due in large part to shared risk factors, and the accumulation of disease with age (Muggah et al., 2012).

The prevalence of multimorbidity is growing in Canada (Roberts et al., 2015; Muggah et al., 2012). There are no precise prevalence estimates in the general population due to differences in defining multimorbidity, data sources and study populations (Fortin et al., 2012). Estimates vary from 13% to 90% depending on how multimorbidity was measured in a study (Roberts et al., 2015).

Researchers at the Public Health Agency of Canada analyzed 2011 to 2012 data from the Canadian Community Health Survey on the prevalence and correlates of multimorbidity in the general adult population (Roberts et al., 2015). Approximately 13% of Canadians reported having

two or more chronic diseases and 4% reported having three or more (Roberts et al., 2015). The prevalence of multimorbidity was associated with older age, female sex, and lower household education and income levels. Social deprivation was associated with nearly four times the odds of mutimorbidity in the overall population (Roberts et al., 2015). This study also confirmed prior research reporting that the likelihood of multimorbidity was associated with increased number of modifiable lifestyle factors (Fortin et al., 2012).

An Ontario-based study estimated the population-based prevalence and trends of multimorbidity using health administrative data and reported one-in-four Ontarians have at least two chronic conditions (Pefoyo et al., 2015). The prevalence of multimorbidity increased by 40% from 2003 (17.4%) to 2009 (24.3%); compared to only a 4% increase in the prevalence of a single chronic disease over the same period (Pefoyo et al., 2015).

Muggah and colleagues (2012) examined the patient and health system burden of multiple chronic conditions among Ontario adults. They reported that the burden of care for patients with multimorbidity largely fell on primary health care providers, and the annual mean primary health care use increased significantly with each additional chronic disease (Muggah et al., 2012).

There is a need to further examine the individual and health system impacts of multimorbidity to better contextual quality of life and health outcomes (Diaz et al., 2015; Roberts et al., 2015; Viola´n et al., 2014; Muggah et al., 2012).

1.4.4 Immigrant and Refugee Health

Immigration influences both the structural and intermediary determinants of health that operate in the context of experiences and exposures both pre- and post- migration. In Canada, the incidence and prevalence of chronic disease is different amongst Canadian born and non-Canadian born populations (Pottie et al., 2011). Over time, the risk of non-Canadian born individuals developing chronic health problems surpasses that of the Canadian born population (Beiser, 2005;

Chiu et al., 2011). This transitioning '*healthy immigrant effect'*, was previously observed among migrants originating from European source countries, and those settling in Canada as Economic class migrants (Beiser, 2005; DesMeules et al., 2005). Rigorous medical screening protocols have historically been in place to ensure that only the healthiest and most adaptable migrants were selected to settle in Canada (Beiser, 2005). The CSDH model is used in this thesis to conceptualize the causes and risk factors for the development of chronic conditions and enables us to better understand how these factors interact and impact health inequities and outcomes among immigrants compared to the general population.

Factors contributing to the initial health advantage and subsequent deterioration of immigrant populations are complex and include selective immigration policies, access to health care, and acculturation, as depicted in our conceptualized approach to understanding immigrant health within the context of the CSDH model (Constant, 2017; Antecol & Bedard, 2015; Kennedy, Kidd, McDonald, & Biddle, 2015; Moullan & Jusot, 2014).

The healthy immigrant effect and its relationship with duration of residency in a host country is not always consistent when health outcomes are examined across different demographic groups (Gee, Kobayashi, & Prus, 2004; Kobayashi & Prus, 2012; Oza-Frank & Venkat Narayan, 2010). Factors such as gender, race, ethnicity, type of immigrant and age at time of arrival can impact outcomes across the immigrant population (Constant, 2017; Antecol & Bedard, 2015). Other factors such as the sample (comparison group, year of study) and methodological approaches accounting for cohort effects can impact the degree to which immigrants experience better or worst health (Antecol & Bedard, 2015).

Immigration to Canada from non-European regions, such as South Asia, sub-Saharan Africa and Latin America, has been increasing over the last few years (Pottie et al., 2011). Legislative

policy amendments removing routine medical screening tests (described below), have also led to an influx of refugee migrants from world regions with high rates of chronic conditions (Mayhew et al.,

Over the years, Canada has undergone several immigration policy changes which constitutes a part of the socioeconomic and political context of the structural determinants that impact the intermediary determinants of health (i.e., the more proximal influences that impact health). In 2002, the government of Canada enacted the Immigrant and Refugee Protection Act (IRPA) impacting the composition of future refugees entering Canada (Beiser, 2005; Gushulak, 2010). This shifted federal government priorities from ensuring successful integration of refugees to their protection and safety. Medical screening protocols have traditionally been in place to ensure that the healthiest and most adaptable immigrants and refugees are accepted into Canada (Mayhew et al., 2015; Rouhani, 2011).

Following the IRPA, the government modified the medical screening criteria and has been accepting refugees that are more disadvantaged and less likely to adapt to Canadian culture than previous refugees since 2002 (Beiser, 2005; Gushulak, 2010; Rouhani, 2011). As a result, refugees that have entered Canada following the IRPA have a greater risk of experiencing poor health outcomes with limited adaptability to Canadian culture than previous cohorts (Rouhani, 2011; Mayhew et al., 2015). This shift in policy, conceptualized as a structural determinant of health, can have significant implications both within and beyond the health care system. It not only impacts demographic characteristics of refugees that are accepted and resettled into Canada but may contextualize cohort differences in the health status of refugees settling in Canada after 2002 and in turn how they experience health outcomes post- migration (Rouhani, 2011).

The IRPA also recognizes the importance of the family as an integral part of immigration and lists family reunification as a key objective. Historically, family reunification has played an important role in shaping immigration policy in Canada. The range of individuals included under the

family reunification category has varied for decades (DeShaw, 2006). Under the IRPA, individuals can be sponsored based on their relationship to the sponsor (Canadian citizen or permanent resident) as a spouse, common-law partner, child, parent, or other prescribed member of the sponsor. The latter includes an extended list of eligible individuals such as conjugal partners, grandparents, persons who are orphaned, and individuals under 18 years of age as brothers, sisters, nieces, nephews, or grandchildren (DeShaw, 2006). This IRPA reflects Canada's commitment to achieving increased social cohesion by enabling Canada to pursue social, economic, and cultural benefits through immigration coupled with enriching the social and cultural fabric of Canadian society. This policy change can also have significant impact on the socio-demographic profile of immigrants landing to Canada after 2002 and highlights the need for evidence-based data to inform the discourse on immigration and its socio-economic impact on Canadian society (DeShaw, 2006).

1.4.5 Risks for Chronic Disease among Immigrant and Refugee populations

Ethnic differences, attributed to both genetic predisposition (non-modifiable) and behavioural (potentially modifiable) factors, contribute to an elevated risk of disease, over time, both prior to and after settlement in Canada (Benchimol, Manuel et al., 2015; Tu et al., 2015; Creatore, 2013; Rosella et al., 2012; PHAC, 2015; PHAC, 2012). Immigrants from high endemic regions develop chronic diseases, such as diabetes at a younger age than Canadian-born Caucasians (Creatore et al., 2010). The reasons for these differences are likely multifactorial and are not fully understood.

The risk of chronic disease varies, depending on ethnicity. For example, individuals of South Asian, Latin, Chinese or African backgrounds have an increased risk for developing certain types of disease such as diabetes compared to Caucasians (Langellier et al., 2012; Dassanayake et al., 2012; Chiu et al., 2012; Chiu et al., 2011; Ekoe et al., 2008). Findings from genomic studies also reported genetic differences by ethnicity for elevating the risk of certain chronic diseases (PHAC,

2015; National Research Council, 2004). For example, South Asians have greater susceptibility for developing insulin resistance at a younger age and at lower BMIs compared to North American Whites (Gujral et al., 2013).

Chiu and colleagues (2015) examined temporal trends in cardiovascular disease risk factors among white, South Asian, Chinese, and black groups in Ontario from 2001 to 2012 using data from the CCHS and observed important ethnic differences. They reported the prevalence of diabetes increased 2 to 3 folds among South Asian males and black females, the prevalence of obesity increased across all ethnic groups, and the prevalence of hypertension significantly increased among black females (Chiu et al., 2015).

Emerging studies have also shown that early-life exposures may trigger a genetic predisposition to developing certain conditions among immigrants, including their children born in Canada many years after migration (Benchimol, Manuel et al., 2015). Benchimol, Manuel and colleagues (2015) examined the risk of immune-mediated diseases among South Asians and other immigrants in Ontario, including their Canadian-born children. Adult immigrants from South Asia had a higher risk of asthma and lower incidence of Inflammatory Bowel Disease (IBD) compared to non-immigrants. The risk of disease was higher among Canadian-born children of South Asian immigrants, relative to children of non-immigrants, despite lower rates observed among immigrant children from South Asia (Benchimol, Manuel et al., 2015).

A population-based study reported a 30% lower age-standardized incidence rate of major cardiovascular events among immigrants than long-term residents in Canada (Tu et al., 2015). East Asian immigrants (mostly ethnic Chinese) had the lowest incidence, but rates increased with greater duration of stay in Canada. South Asian immigrants had the highest event rates, along with immigrants from Iraq and Afghanistan (countries with the highest number of refugee immigrants).

Adjustment for traditional risk factors reduced, but did not eliminate, differences in cardiovascular risk between various ethnic groups and long-term residents (Tu et al., 2015).

Okrainec et al. (2015) also reported a healthy immigrant advantage with diabetes among recent immigrants compared to long-term residents in Ontario, and a lower adjusted risk of cardiovascular events that persisted beyond ten years from immigration. However, this health advantage was not observed among recent refugees, immigrants with no previous education and those who were unmarried (Okrainec et al., 2015).

The deteriorating health among immigrants, over time, may result from exposure to the physical, social, cultural and environmental effects of their resettled country (i.e., the socioeconomic and political context such as governance, macroeconomic, social and public policies) cultural and societal values that influence the acculturation process of migration, all of which impact socio-economic factors that determine social positional and the material circumstances that amplify disparities and health outcomes post-resettlement (Kliewer and Smith, 1995a; Kliewer and Ward, 1988; Dunn and Dyck, 2000; Beiser, 2005).

After settlement in Canada, changes in lifestyle and behaviours related to acculturation (i.e., adoption of lifestyle habits such as Western diet and changes in levels of physical activity), and barriers to accessing primary care services contribute to an elevated risk for chronic disease (PHAC, 2015; PHAC, 2012; Beiser, 2005). However, there are no directly linked reports on such post-migration factors to an elevated risk of developing chronic disease, over time.

Cross-sectional analyses from the CCHS have found ethnic differences in modifiable risk factors such as lifestyle habits (PHAC, 2015; PHAC, 2012). For example, individuals of Chinese descent were 1.6 to 6.0 times less likely to be obese but reported higher rates of physical inactivity. Other ethnic groups (e.g., Chinese, or Filipino) reported less consumption of fruits and vegetables

compared to Canadian-born Whites (PHAC, 2015; PHAC, 2012). The associations of these risk exposures with the likelihood of developing chronic disease, over time, remains unknown.

Socio-economic positioning, among different immigrant groups, may affect outcomes; despite the healthy immigrant advantage observed in the overall immigrant population. Shortcomings in immigration and resettlement policies can potentially further jeopardize immigrant's health advantage (Beiser, 2005). After immigrants arrive in Canada, their health falls under provincial jurisdictions, despite immigration being a federal responsibility. Strategies addressing the social determinants of health, through immigration health policy and program planning may help in the primary prevention of disease (Manuel et al., 2016; Beiser, 2005).

1.4.6 The Social Determinants of Health and Inequities: The Migration Experience

Immigrants differ by country of origin, their entry category (refugee, economic and family reunification immigrants), previous exposure to illness and health behaviours, levels of acculturation, cultural retention; all of which can stress amplify health inequities, and in turn affect their health outcomes (Hyman, 2010; Beiser, 2005).

Resettlement experiences in the host country impact the health of immigrants and refugees. Factors such as unemployment, poverty, and lack of access to health and social services are universal health risks for everyone but heightened among all immigrants during the resettlement process. The likelihood of exposure to these factors is further amplified by social exclusion and discrimination (Beiser, 2005).

Understanding the health of immigrants and refugees requires an integrative approach and includes consideration of pre- and post- migration processes that influence health outcomes. This includes genetic, ethno-specific predispositions, pre-migration exposures, post-migration stressors, individual and social resources (Beiser, 2005).

There are several reported health disparities, at arrival, across migrant groups (immigrants vs refugees) and by country/regions of origin. These disparities are apparent when immigrants and refugees arrive and after they settle in Canada (Okrainec et al., 2015; DesMeules et al., 2005; Mayhew et al., 2015; Rouhani, 2011; Beiser, 2005). Refugees arrive in poorer health; have greater health needs, and greater vulnerability to disease and illness than other immigrants due to their pre-migration and resettlement experiences in Canada (McKeary and Newbold, 2010). A pan-Canadian, population-based data linkage found an increased risk of mortality among refugees stratifying by immigrant type, compared to the Canadian-born group (DesMeules et al., 2005).

Socio-demographic and historical differences between refugee populations lead to different pre-migration health outcomes. Refugees arrive in poorer health due to the stressful psychosocial effects of trauma, direct and indirect effects of war and conflict, refugee camp internment in low-income countries and/or warn torn regions and long-standing lack of access to curative and preventive healthcare prior to arrival in Canada (Mayhew et al., 2015; Rouhani, 2011; Hyman, 2010).

Refugees also face greater difficulty during the migration voyage, having been prone to violence, hunger and/or exposure to infectious and other preventable diseases; all of which amplify their migration stress (pre-and post-arrival) and aggravate latent health problems (Hyman, 2010; Beiser, 2005; Rousseau & Drapeau, 2004; Pottie et al., 2006; Oxman-Martinez and Hanley, 2005). These differences may also trigger stress related outcomes by reducing the ability to cope with acculturation, leading to poor health (Matheson et al., 2007; Hyman, 2010).

Post-settlement experiences further impact immigrants and refugees differently. A Canadian study examined the health status of refugees' post-settlement in Alberta. Having employment and receiving a greater number of settlement services were associated with improvements in overall mental and physical health (Maximova and Krahn, 2010). Having a higher education in one's home country and perceived sense of economic hardship were associated with a

greater decline in health, compared to refugees with lower educational levels (Maximova and Krahn, 2010).

1.4.7 Healthcare Utilization

Access to and utilization of healthcare services plays an important role in the development of chronic disease. Individuals who face barriers accessing primary care may be at risk for delayed diagnosis and disease prevention (PHAC, 2016).

Across several provinces and territories in Canada, new immigrants, are subject to a 2-3 month waiting period for access to provincial health insurance. In Ontario, a 3-month waiting period is imposed for all landed immigrants. Government-assisted refugees and privately sponsored refugees are not subject to the waiting period and receive health coverage upon arrival in Ontario through the Ontario Health Insurance Plan (OHIP) or the Interim Federal Health Program (IFHP) (Goel, Bauch and Caulford, 2013). There is limited research addressing the waiting period policy in Ontario, despite evidence in the literature showing poorer health outcomes for individuals who do not have medical and health coverage in Canada. Most of the research to date has focused on asylum seekers, refugee claimants and undocumented individuals (Kuile et al., 2007; Khan et al., 2010; Goel, Bauch and Caulford, 2013). In Toronto, a study based in a volunteer health clinic examined identified 36% of its patient population as landed immigrants seeking care during the 3-month waiting period suggesting attempted access and a need to obtain healthcare services (Caulford & Vali, 2006). In 2006, the Ontario Medical Association issued a policy position statement on the negative implications of the 3-month waiting period and poor access to care calling for an end to the waiting period policy. The paper cites evidence that when care is delayed during the waiting period, it is immediately sought after 3-months incurring the same financial costs as it would have during the waiting period (OMA, 2011). A qualitative study in Toronto described the experiences of new immigrants who were subject the waiting period, required healthcare services

during that time and obtained care at a local volunteer clinic. Several emerging themes indicated significant negative experiences including lack of information, financial loss related to health care, emotional hardship, and poor health outcomes indicating the potential consequences of the waiting period and advocating its removal (Goel, Bauch and Caulford, 2013).

Within Canada, temporary limited coverage of health care services is provided to certain groups such as resettled refugees and claimants under the Interim Federal Health Program (IFHP) (Government of Canada, 2020). The IFHP is a federal program under the auspices of the Department of Immigration, Refugees and Citizenship Canada that has been amended from time to time under different governments. The IFHP also provides coverage for certain pre-departure medical services to refugees settling into Canada prior to their arrival (Government of Canada, 2020). The program does not cover all migrants in Canada who are not covered by provincial health insurance plans. The program is intended only to provide temporary coverage on an interim basis (Government of Canada, 2020). The IFHP provides limited, coverage of health-care costs for basic, supplemental and prescription drug benefits for specific groups such as resettled refugees and refugee claimants during their period of ineligibility for provincial health insurance (Government of Canada, 2020).

Even after the 3-month waiting period, the literature has reported immigrants and refugees to have poorer access and lower utilization of healthcare services due to barriers in navigating the system or obtaining a family doctor (McDermott et al., 2010; Booth et al., 2007). This leads to unmet needs and contributes to the elevated risk of developing a chronic condition (Rouhani, 2011; Setia et al., 2010; Lebrun et al., 2010; Booth et al., 2007). A recent population-based study examined breast cancer screening disparities among immigrant women, by world region of origin (Vahabi, Lofters, Kumar, Glazier, 2016). Rates varied according to world region of origin. Factors associated with lower rates included living in the lowest income neighborhoods, having a refugee status, being a

new immigrant to Canada, and not having a regular physical examination (Vahabi, Lofters, Kumar, Glazier. 2016).

Another population-based study reported lower use of mental health services among recent immigrants compared to long-term residents or Canadian born individuals, with varying rates according to world region of origin (Durbin, Moineddin, Lin, Steele, Glazier; 2015).

These studies highlight the importance of culture/ethnicity in determining health service use outcomes (Vahabi, Lofters, Kumar, Glazier., 2016; Durbin, Moineddin, Lin, Steele, Glazier, 2015).

1.4.8 Multimorbidity among Immigrant and Refugee Populations

There is limited research on the impact of migration on the prevalence of multimorbidity (Dassanayake et al., 2012). A population-based study investigated the impact of length of stay in Norway on the prevalence of multimorbidity across immigrant groups (Diaz et al., 2015). The healthy immigrant effect was apparent for all immigrant groups upon arrival; however, multimorbidity doubled for all immigrants (refugees, labour immigrants, and family reunification and education immigrants) after five years of settlement in Norway. Rates were highest among refugees compared to other immigrant groups (OR=1.67 and OR=1.83) for both men and women respectively (Diaz et al., 2015).

In Canada, research on the prevalence and determinants of multimorbidity among immigrants and refugee populations is limited. Roberts et al. (2015) examined the CCHS data by using self-reported immigration status (those living in Canada for less than 5 years, more than 5 years, and Canadian-born). They reported a healthy immigrant effect for all immigrant respondents. However, the prevalence rate of reporting two or more and three or more chronic diseases drastically increased after living in Canada for five or more years compared to less than five years (11.6% vs. 2.3% for 2 or more chronic diseases and 3.4% vs. 0.5% for 3 or more chronic diseases)

(Roberts et al., 2015). Due to its cross-sectional study design, this study was unable to capture differences between immigrant groups and causal relationships.

It is important to recognize the complex interrelationships between various risk factors and chronic health conditions. Traditional, single-disease approaches may be inappropriate in the Canadian context given the alarming rise of multimorbidity (Muggah et al., 2012). It is important to develop an integrated approach to prevent the development of diseases to identify cost- efficient approaches to improving quality of life and health service delivery (Roberts et al., 2015; Diaz et al., 2015).

1.5 KNOWLEDGE GAPS IN THE SCIENTIFIC LITERATURE

There are knowledge gaps on the role of biological-environment interactions in the development of chronic disease. To our knowledge, no study has considered multiple risk factors (modifiable and non-modifiable, pre-and post- migration), and how these factors interact in the development of chronic conditions among different immigrant populations.

No studies have longitudinally examined the development of multiple chronic condition outcomes, the factors associated with this risk across different immigrant populations, and how their risk differs from the general Canadian population.

Previously, there have been limitations addressing differences among immigrants and refugees with a heavy reliance on self-reported data in migration research. Current work has largely focused on describing risk levels, but not on identifying the cause of the risk. Studies have not looked at the combination of risk exposures and the likelihood of developing multiple chronic diseases over time. Existing research has only targeted a segment of this diverse population or treated immigrants as a homogeneous group. Immigration status data has only recently been available for in depth research. Only recently, has immigration data from Immigration, Refugees and Citizenship Canada been made available to select provinces for research purposes.

1.6 THESIS OBJECTIVES AND RESEARCH QUESTIONS

Objective 1: Chronic condition outcomes among different immigrant categories (CHAPTER 2)

Research questions:

1. What is the risk over time for developing a chronic condition among different immigrant populations compared to long-term residents of Ontario?
2. Does this risk differ by an immigrants' visa category and world regions of origin?

Objective 2: Rates and patterns of multimorbidity across immigrant categories (CHAPTER 3)

Research questions:

1. What are emerging patterns of multimorbidity among different immigrant categories and long-term residents of Ontario?
2. Is the risk of multimorbidity, over time, higher across different immigrant categories compared to long-term residents of Ontario?
    a. Does this risk vary by world regions of origin?

Objective 3: Cohort effects for chronic condition outcomes among different immigrant populations (CHAPTER 4)

Research questions:

1. Is there a difference in the risk of developing a chronic condition among immigrant cohorts migrating at different points in time?
    a. How does this risk compare to long-term residents of Ontario?
    b. Do cohort effects vary by immigrant visa category?

1.7 IMPACT AND RATIONALE FOR THIS THESIS

The increase in global chronic disease rates, coupled with rising immigration from low- and middle- income countries to Canada, highlight the need to longitudinally examine common risk

factors across different immigrant populations (from different world regions of origin, with different pre- migration exposures) on the likelihood of developing a chronic condition and multimorbidity in Canada (Tu et al., 2015; Yusuf et al., 2014).

Since many chronic conditions share common risk factors, individuals with a certain set of risk factors, will likely suffer from more than one condition (Muggah et al., 2012). Existing clinical evidence and guidelines focus on the management of singular diseases, making its applicability limited to other chronic conditions (Muggah et al., 2012). Understanding the impact of these shared common risk factors on overall health will inform how chronic conditions can be better managed with similar strategies that provide more efficient, coordinated, and cost-effective care.

As such, the development of chronic conditions is examined both individually and collectively to better understand how the overall health of immigrants is impacted by shared common risk factors to inform prevention strategies that address a spectrum of improvements in health.

All three manuscript-based chapters in this thesis utilize a matched retrospective observational cohort design with data ranging from 1995 to 2016. It includes an open cohort of individuals entering the study, at different points in time, using routinely collected administrative data at ICES. Each chapter examines a specific research objective, utilizing the same data. The objectives are different in scope but are interrelated as they inform policies and interventions aimed to reduce health inequities that impact health outcomes across different immigrant populations.

The conceptual framework used in this doctoral dissertation informs our analytical approach, as well as our interpretation of data and implications for future program and policy planning. This doctoral dissertation will be the first of its kind to longitudinally examine the impact of immigration as a social determinant of health across different immigration visa categories (economic, family and refugee immigrants), arriving at different points in time (defined as landing

cohorts), from major world regions of origin (as a proxy for ethnicity/country of origin), and diverse socio-demographic profiles, on a wide range of health outcomes at the population-level.

The objectives will be studied using this approach, in consideration of the CSDH framework, that conceptualizes health inequities and well-being as a cumulative result of multiple factors that impact health across the structural and intermediary determinants of health. We conceptualize immigration as an intermediary determinant of health, impacted by both pre- and post-migration factors (type of immigrant, region of origin), material circumstances (income level post-arrival), biological factors (age, sex, region of origin as a proxy for ethnicity), but also consider the societal and political context that shape governance affecting immigration policies that impact the cohorts of immigrants arriving and settling in Canada across different points in time.

The analyses presented throughout this dissertation support our framework intended to address each research question. We analyzed the effect of immigration, utilizing statistical analyses that stratify and control for the heterogeneity among immigrant populations, in consideration of the pre- and post-migration factors that shape inequities and determine health outcomes.

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CHAPTER 2 - RISK OF DEVELOPING A CHRONIC CONDITION AMONG IMMIGRANT AND LONG-TERM RESIDENTS OF ONTARIO BETWEEN 1995-2016

ABSTRACT

Background: Over recent years, immigration to Canada has been increasing. We examined the risk for developing a chronic condition among different healthy immigrant populations compared to long-term residents of Ontario, and how this risk differed by an immigrants' visa category and world region of origin.

Methods: This study used a 1:1 matched retrospective observational cohort design from 1995 to 2016 and included an open cohort of individuals entering the study, at different points in time, using routinely collected population-based administrative data at ICES. Our outcome variable consisted of the incidence of one of nine chronic conditions (asthma, Chronic Obstructive Pulmonary Disease, rheumatoid arthritis, acute myocardial infarction, congestive heart failure, diabetes, Crohn's and colitis disease, cancer, and hypertension) from previously validated ICES-derived disease cohorts. Stratified and multivariate Cox Proportional Hazard models were used to examine the risk of developing a chronic condition over time between immigrants and long-term residents, by immigrant visa category and further by world regions of origin.

Results: A total of 2,312,244 immigrants and long-term Ontario residents were included in the study. After controlling for age, sex and neighborhood level income quintiles, refugees had the highest hazard [HR] (HR: 1.19, 95% CI: 1.17 – 1.21) of developing a chronic condition compared to long-term residents of Ontario. Family (HR: 0.97, 95% CI:0.96 – 0.98) and economic class immigrants (HR: 0.88, 95% CI: 0.87 – 0.89) had a lower risk of developing a chronic condition compared to long-term residents. Moreover, the risk of developing a chronic condition for each immigrant visa category, varied by world regions of origin. Immigrants from the Caribbean and South Asia had a higher risk of

developing a chronic condition, across all immigrant categories, compared to long-term residents. The risk of developing a chronic condition was higher among refugees from sub-Saharan Africa (HR: 1.21, 95% CI: 1.17 – 1.25) and North Africa and the Middle East (HR: 1.08, 95% CI: 1.03 – 1.13), and family class immigrants from sub-Saharan Africa (HR: 1.10, 95% CI: 1.05 – 1.15) compared to long-term residents of Ontario.

Conclusions: The risk of developing a chronic condition was heterogenous and varied by immigrant visa category and world regions of origin. Our findings highlight the importance of considering the intersections of socio-demographic factors with migrant characteristics, such as immigrant category and world regions of origin when examining chronic health outcomes across immigrant populations.

2.1 INTRODUCTION

2.1.1 Background

Chronic diseases such as cancer, diabetes, cardiovascular and respiratory diseases are a global concern, with increasing incidence rates in both the developed and developing world (WHO, 2015; PHAC, 2016). They are among the most serious health problems and incur costs to governments, communities, and individuals (Hospedales & Jané-Llopis, 2011). Deaths from chronic diseases are often avoidable (Roberts et al., 2015; WHO, 2015; PHAC, 2016). In 2012, 68% of deaths worldwide resulted from heart disease, cancer, stroke, diabetes, and respiratory illnesses. In Canada, one in three individuals live with at least one major chronic disease (Roberts et al., 2015; Ronksley et al., 2014), that resulted in 27% premature deaths of individuals under the age of 70 in 2012 (WHO, 2015).

In recent decades, Canada has experienced a major increase in immigration. Statistics Canada estimates that by 2031 the proportion of foreign-born Canadians will increase to 28% (Cymbal & Bujnowski, 2010; Statistics Canada, 2006; Beiser, 2005). In 2017, Canada accepted over 286,000 landed immigrants (Immigration, Refugees and Citizenship Canada, 2018). Ontario is home to the largest population of immigrants in Canada. In 2017, 111,929 permanent residents settled in Ontario including 20,191 resettled refugee and protected persons (Government of Canada, 2019).

In Canada, the prevalence and incidence of chronic disease is different amongst Canadian and non-Canadian born populations (Pottie et al., 2011). Over time, the risk of immigrants developing chronic health problems surpasses that of the Canadian born population (Beiser, 2005; Chiu et al., 2011). This transitioning 'healthy immigrant effect', was previously observed among immigrants coming from European source countries, and those settling in Canada as Economic

class migrants. Rigorous medical screening protocols were in place to ensure that only the healthiest and most adaptable migrants were selected to settle in Canada (Beiser, 2005).

Over recent years, immigration to Canada from non-European regions, such as South Asia, sub-Saharan Africa and Latin America has been increasing (Pottie et al., 2011). Legislative policy amendments in Canada, such as the Immigrant and Refugee Protection Act in 2002, have also shifted the socio-demographic landscape of incoming refugees with changing priorities to select refugees for their protection and safety and less on their health status and ability to successfully integrate into Canadian society (Durbin et al., 2015; Mayhew et al., 2015; Rouhani, 2011).

In the context of migration, health is associated to both pre- and post- migration factors that can differentiate the way in which immigrants experience better or worse health. Socio-demographic and historical differences between different immigrant populations lead to different post-migration health outcomes (Beiser, 2005). Factors such as an immigrant's visa entry category (refugee, family and economic immigrants) and their world region of origin (a proxy for ethnicity), can be contextualized as determinants of health outcomes in the pre-migration context (Tu et al, 2015; Creatore, 2013; Beiser, 2005). For example, refugees arrive in poorer health and have greater health needs due to the stressful psychosocial effects of trauma, direct and indirect effects of war and conflict, refugee camp internment in low-income countries and/or warn torn regions, long-standing lack of access to curative and preventive healthcare prior to arrival in Canada; all of which amplify their migration stress and aggravate latent health problems (Hyman, 2010; Rouhani, 2011; Beiser, 2005). These differences may also affect post-migration health outcomes by reducing the ability to cope with acculturation, leading to poor health (Beiser, 2005; Matheson et al., 2007; Hyman, 2010; Rouhani, 2011).

To date, studies have not longitudinally examined the development of a wide range of chronic conditions, and factors associated with this risk, across different immigrant populations

compared to the general population in Canada. Existing evidence has been based on self-reported or cross-sectional data, subject to several limitations, including recall bias and the inability to establish casual relationships. Moreover, previous studies have either examined immigrant populations as a homogenous group, with the inability to examine disparities across different immigrant categories or have studied a sample of immigrant sub-populations that limit generalizations to the broader immigrant and refugee population (Okrainec et al., 2015; Tu et al., 2015; Roberts et al., 2015; Beiser and Hou, 2014; Hempler et al., 2011; Hyman, 2010; Beiser, 2005). Immigration data has also been only available in recent years to select Canadian provinces for research purposes. This study addresses some of these existing knowledge gaps with the opportunity to utilize population-based immigrant and health data available at ICES.

2.1.2 Objective

The main objective of this study is to examine the risk, over time, for developing a chronic condition among different immigrant populations compared to long-term residents of Ontario, and how this risk differs by an immigrants' visa category and world region of origin.

2.2 METHODOLOGY

2.2.1 Ethics

Ethics approval was obtained from the University of Ottawa Health Science and Science Research and Ethics Board. No patients were recruited for the study. This study used de-identified population-based health administrative data at ICES. ICES is an independent, non-profit research institute funded by an annual grant from the Ontario Ministry of Health and Long-Term Care (MOHLTC). As a prescribed entity under Ontario's privacy legislation, ICES is authorized to collect and use health care data for the purposes of health system analysis, evaluation, and decision support. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario.

2.2.2 Study Design, Setting and Data Sources

This study uses a matched retrospective observational cohort design. The study period was from 1995 to 2016 and included an open cohort of individuals entering the study, at different points in time, using routinely collected administrative data at ICES.

Patient Level Data

ICES holds patient-level data consisting of administrative health records for individuals eligible for universal health coverage in Ontario since 1986 (ICES, 2019a). The ICES data Repository contains codes and linkable health datasets of health records for over 13 million individuals in Ontario including population and demographics, ICES-derived disease cohorts (medical profiles), health services use, coding, and geography, financial, social and survey data (ICES, 2019a). This project used the following datasets that were linked using unique encoded identifiers and analyzed at ICES.

Population and Demographics

The Registered Persons Database (RPDB) and Immigrant and Refugees Citizenship Canada Permanent Residents Database (IRCC) were used to identify our study population. We used the RPDB to identify eligible long-term Ontario residents. The RPDB is an electronic registry of all individuals who are eligible for health coverage in Ontario. Information is received from the Ministry of health and Long-term Care including date of birth, sex, date of death, time periods for which an individual was eligible for OHIP coverage and residential postal code. Data supplied by the Ministry is enriched with information from ICES datasets (ICES, 2018a).

We identified immigrants from the IRCC database which contains a registry of all landed immigrants to Canada since 1985. The dataset includes individual-level information on country of origin, immigrant type, education, and other socio-demographic and economic indicators at the time of landing among immigrants who identified Ontario as a declared destination (ICES, 2019b).

Immigrant data from the IRCC database is probabilistically linked to the RPDB. Validation studies on the linkage between the Ontario portion of the IRCC database and the RPBD have shown an 84.4% successful linkage between the two data sources of records (Cernat et al., 2002; Creatore, 2013; Urquia, 2009).

Health Services Use

The Ontario Health Insurance Plan (OHIP) database is the provincial health program that provides publicly funded universal health services through the Ontario Ministry of Health and Ministry of Long-term care to approximately 95% of Ontario residents. ICES contains most claims paid for by OHIP covering all health care providers who can claim under OHIP. This includes physicians, groups, laboratories, and out-of-province providers (ICES, 2017). OHIP does not cover health services for First Nation populations on reserves and members of the Armed Forces who receive health coverage through other federally funded programs (ICES, 2017).

Coding and Geography

Data using the Census area profiles (CENSUS) and Postal Code Conversion File (PCCF+) were collected and used in our study. Statistics Canada conducts a census of the Canadian population every five years presented as area profiles, and contains age, sex, marital status/common law status, mother tongue and other socio-economic data that are collected (Statistics Canada, 2019). The PCCF+ is a file which provides the correspondence between each postal code in Ontario and Statistics Canada standard geographic areas and is updated every five years (ICES, 2013). In our study, we used Census and PCCF+ data for 1996, 2001, 2006 and 2011 depending on the index year for which immigrants and long-term residents entered the study. We used the Census and PCCF+ data to collect sociodemographic information and area of residence based on standard urban and rural geographic areas.

ICES-Derived Cohorts

This study used data for chronic conditions that have been defined from previously validated population-derived ICES cohorts using linked data algorithms that were derived from the Discharge Abstract Data and OHIP claims (Appendix E). We used ICES-derived disease cohorts for the following nine chronic conditions: Asthma[3], Congestive Heart Failure[4] (CHF), Chronic Obstructive Pulmonary Disease[5] (COPD), Hypertension[6] (Hyper), Crohn's and Colitis[7] (OCCC), Diabetes[8] (ODD), Myocardial Infarction[9] (OMID), Rheumatoid Arthritis[10] (ORAD), and cancer[11] (OCR).

2.2.3 Eligibility criteria

Immigrants were required to have landed in Ontario between 1992 and 2010, be 18 to 70 years of age on December 31 of the year of their landing in Ontario; have remained Ontario residents for at least three years and obtained OHIP coverage during that period; have no documentation of any of the nine chronic conditions that can be ascertained with the ICES-derived disease cohort data, as defined above, at the end of that 3-year period. We used a three-year period to allow enough time for immigrants to obtain OHIP coverage and have an interaction with the

[3] Ontario Asthma Dataset (Andrea S Gershon, Wang, Guan, Frcpc, et al., 2009; Andrea S Gershon, Wang, Guan, Vasilevska-Ristovska, et al., 2009; To et al., 2006)
[4] Ontario Congestive Heart Failure Dataset (Schultz, Rothwell, Chen, & Tu, 2013)
[5] Ontario Chronic Obstructive Pulmonary Disease Dataset (A. S. Gershon, Wang, Guan, Vasilevska-Ristovska, et al., 2009)
[6] Ontario Hypertension Dataset (Tu, Campbell, Chen, Cauch-Dudek, & McAlister, 2007; Tu, Chen, & Lipscombe, 2008)
[7] Ontario Crohn's and Colitis Cohort Dataset (E. I. Benchimol et al., 2009; Eric I. Benchimol et al., 2014)
[8] Ontario Diabetes Dataset (Guttmann et al., 2010; Lipscombe et al., 2018)
[9] Ontario Myocardial Infarction Dataset (Austin, Daly, & Tu, 2002)
[10] Ontario Rheumatoid Arthritis Dataset (Widdifield et al., 2013, 2014)
[11] Ontario Cancer Registry (ICES, 2018b)

health care system. We excluded immigrants who were classified as "other" in their admission class category (<5%) and included only those with an immigration visa category classified as a refugee, family, or economic.

Using the RPDB data, we identified all Ontario residents eligible for universal health coverage in the province. Long-term residents of Ontario must have been Ontario residents for at least ten years prior to entering the study; be free of any of the nine chronic conditions, and not have been in the IRCC database at any time. Since we only have OHIP records from 1991 onwards, we cannot ascertain OHIP eligibility from birth for those born prior to 1991. For individuals born in 1991 to 1992, they must be OHIP eligible at birth. The long-term Ontario residents are mostly born in Canada but may include immigrants who have settled in Ontario before 1985. Since we only have OHIP records from 1991 onwards, we cannot ascertain OHIP eligibility from birth for those born prior to 1991. To avoid potential misclassification of immigrants as long-term residents, individuals in the long-term Ontario resident cohort must have had an Ontario postal code before January 1, 1994, must have had OHIP eligibility from 1991 to 1994 and not be in the IRCC database at any time simultaneously (refer to Appendix for a diagram of the immigrant and long-term resident cohort creation).

2.2.4 Matching

Immigrants who landed in Ontario from 1992 to 2010 were identified from the IRCC database. Once eligible, they were each matched 1:1 to a long-term resident based on age (year of birth), sex, rurality (Rurality Index Ontario (RIO) >45 [yes/no] from the RPDB and PCCF+. Eligible long-term residents of Ontario were each matched only once to each immigrant. The dataset was limited to all immigrants and their matched control. The individuals in the matched cohort were then linked to the other ICES datasets used in this study (refer to Appendix B for an illustration of the immigrant and long-term resident cohort creation and matching).

2.2.5 Variables

Outcome Variables

Our primary outcome consisted of the incidence of any of the nine chronic conditions from the ICES derived disease cohorts listed above that were available at the time of the study. We also examined the individual incidence of each chronic condition. We examined the risk of chronic conditions both individually and collectively to better understand how the overall health of immigrants is impacted by their shared common risk factors, that are not limited to a singular disease, to inform prevention strategies that address a spectrum of improvements in health.

Independent Variables

Our data contained several socio-demographic and immigration variables that were made available from the linked ICES datasets in our study (refer to Appendix F for a complete list of variables and their respective datasets). Our primary covariate of interest was whether an individual was an immigrant (yes/no), identified from the IRCC database, and belonging to one of the three immigrant categories (refugee, family, or economic immigrant - (refer to Appendix C for a list of how immigrant categories were grouped using data from the Immigration, Refugee and Citizenship Canada Landed Immigrant Dataset) as our primary covariate. Our socio-demographic variables included age (categorized as 18-29, 30-44, 45+) and sex (Male/Female) directly derived from health administrative records.

We also used neighborhood level income, derived from Census area profiles and the PCCF+ data files since individual-level data was not available in our immigration or health datasets.

Residential postal code for an individual was linked to dissemination- level income data[12] collected for the 1996, 2001, 2006 and 2011 Canadian census using the PCCF+ files corresponding to the respective Census files. The Census files assign relative income quintiles based on the smallest geographical unit for which the census data is available and is adjusted for household and community size. This is a method that has previously been used with ICES data (Creatore, 2013; Wilkins, 2001). The selection of a specific file year depended on the index year for which immigrants and long-term residents entered the study observation period.

Immigration variables were derived from the IRCC database containing individual-level information on their immigration visa category. Most immigrants enter Canada as one of the following: economic (i.e., those who come under a business class visa or bring in needed skills), family (spouses, common-law partners, or immediate family members such as dependent children or parents) and refugees (individuals in need of safety and protection and recognized as United Nation Convention refugees prior to entering Canada) (Immigration, Refugees and Citizenship Canada, 2018).

The IRCC database also contains information on an immigrants' country of origin, their year of landing in Ontario, education level (categorized in this study as: Secondary or less, Non-University Qualifications/Some University, or University degree or higher) and official language proficiency (English, French or both/None) (ICES, 2019b). Since the IRCC database included

[12] The dissemination area is a small area used by Statistics Canada composed of one or more neighboring dissemination blocks and is the smallest standard geographic area for which all census data are disseminated. The number of dwellings in a dissemination across Census years across rural areas and large urban centres (Census Metropolitan Areas) (Statistics Canada, 2019).

immigrants from over 200 different countries, we grouped countries into world regions of origin (refer to Appendix D for a list of how countries of origin, derived from the IRCC database, were grouped together) based on the World Bank schema and further by ethnic grouping to obtain the following categories: the Caribbean, East Asia and the Pacific, South Asia, Eastern Europe and Central Asia, North Africa and the Middle East, Latin America, Western Europe and the US, and sub-Saharan Africa (Lazo-Langner et al., 2018; Vahabi et al., 2016; Durbin et al., 2015; Urquia et al., 2015; Cretore, 2010). We also grouped individuals by their landing year to create five distinct landing cohorts of immigration to include as a covariate in our analyses – those landing between 1992-1995, 1996-1999, 2000-2003, 2004-2007, and 2008-2010. These categorizations were arbitrary, aimed at producing five distinct landing cohorts of the same interval, except for the 2008-2010 group.

2.2.6 Statistical Methods

Descriptive Analysis

We calculated baseline descriptive statistics for socio-demographic (age, sex, neighborhood income quintiles) and immigrant-specific characteristics (world regions of origin, level of education, language proficiency, and landing cohort [grouped by year of arrival] for immigrant categories, and where applicable, for long-term residents of Ontario. We examined the incidence of the outcome variable, single chronic conditions as well as the type of chronic condition that was first diagnosed for different immigrant categories and long-term Ontario residents (n%).

Overall estimate of risk

We were interested to calculate the risk for developing a chronic condition between different immigrant categories (refugees, family, and economic class immigrants) and long-term Ontario residents during the follow up period of 1995 to 2016. We defined risk as the number of events (a diagnosis of one out of the nine chronic conditions)/1000 person-years. Disease-free immigrants and long-term residents were followed forward in time from study start date (baseline)

to last follow-up (diagnosis of a chronic condition, death, loss of OHIP eligibility, or end of the study observation period).

We calculated incidence rates, per 1000 person-years follow-up, for the development of a chronic condition (outcome variable) for each immigrant category and long-term Ontario resident. We then estimated the relative risk for each immigrant category compared to long-term Ontario residents. Stratified analyses were also performed to estimate the relative risk for immigrant categories, by sociodemographic (age, sex, neighborhood income quintiles) and migration profile (world regions of origin, landing period, education, and language proficiency upon landing), compared to long-term residents.

We also examined the relative risk of individual chronic conditions for each immigrant category compared to long-term resident. This was done to ascertain the risk of individual conditions among immigrants compared to long-term residents of Ontario, and how the risk differs across immigrant categories. When we examined the proportion of individuals with each chronic condition, the prevalence of hypertension and diabetes was the highest among all immigrants, compared to other chronic conditions included in our analyses. To better understand the trends and patterns of chronic conditions, including risk factors, among immigrants, we carried out sensitivity analyses by excluding hypertension and diabetes in our primary outcome measure when estimating the relative risk of our outcome for immigrant categories compared to their matches. Diabetes and hypertension are among the most prevalent global chronic conditions, with a high prevalence in the immigrant population (Van Den Akker, Buntinx, Roos, & Knottnerus, 2001; Creatore, 2013). There is also considerable evidence of an increased risk of hypertension among individuals diagnosed with diabetes, because of shared genetic or environmental factors in etiology (Cheung and Li, 2012). Prevalence depends on age, sex, race/ethnicity, and duration of diabetes prevalence. This overlap in etiology and disease mechanism is a result of common pathways that include obesity and insulin

resistance (Cheung and Li, 2012). As such, there is also a strong association between hypertension and diabetes with lifestyle and behavioral factors such as smoking and physical inactivity (Alter et al., 2012). Hypertension and diabetes are also the two leading risk factors for atherosclerosis, including heart attacks and stroke (Cheung and Li, 2012). A recent systematic review examined this association and found hypertension and diabetes to be predictive risk factors for these chronic conditions (Alloubani, Saleh and Abdelhafiz, 2018). For these reasons, we wanted to examine whether hypertension and diabetes are the driving factors of developing any chronic condition, across different immigrant categories, when compared to long-term residents of Ontario.

Regression modelling

We used Cox Proportional Hazard Models to examine the risk of developing a chronic condition over time. Disease-free immigrants and long-term residents were followed from baseline to event (diagnosis of a chronic condition) or last follow up. Individuals for whom death, loss of OHIP eligibility or the end of the observation period occurred before the event were censored at that date.

To account for the heterogeneity among immigrant populations, conceptualized by the CSDH framework on the social determinants of health, we examined the risk of developing a chronic condition across different strata of immigrant populations when compared to long-term residents of Ontario, by an immigrants' visa category and further by their world regions of origin. We hypothesized there are differences across immigrant visa categories based on known disparities and empirical research that speak to pre- and post-migration factors impacting settlement and health outcomes of immigrant populations.

This informed our analytic approach to stratify our regression analyses by immigrant visa categories. Based on existing knowledge and post-hoc analyses, we further hypothesized differences

in the effect size of being an immigrant, on health outcomes, by an immigrants' world region of origin when comparing their risk to long-term residents.

First, we built three stratified multivariate models, by immigrant visa category (refugee, family, economic class immigrants) to estimate the hazard ratio (HR) and 95% Confidence Intervals (CI) of developing a chronic condition, for each immigrant category, compared to long-term residents. The multivariate models were adjusted by immigrant status, age, sex, and neighborhood-level income quintiles[13] depicted in the following formula as:

Chronic Condition Outcome= Immigrant (yes/no) + Age Category + Sex + Neighborhood level income

We then examined the risk of developing the outcome for immigrants, by their world regions of origin.

We used the same stratified models depicted above and added an interaction term for immigrant status (yes/no) and world regions of origin to estimate the risk for immigrants, by their world region of origin, when compared to long-term residents.

Each long-term resident was assigned the same immigrant visa category and world region of origin as their matched immigrant counterpart to enable a group-to-group comparison (using the

[13] We did not perform a matched-paired analysis. We used Cox Proportional Hazard models to do group comparisons between immigrants and long-term residents and adjusted for age and sex in the multivariate models, which were variables used to match immigrants and long-term Ontario residents in the study design. This is an approach recommended in previous existing literature (Sjölander & Greenland, 2013). Appendix G provides a detailed discussion on the rationale for using this approach.

same sample that did the 1:1 matching), when comparing the effect of immigration on the risk of developing a chronic condition, for immigrants across different world regions of origin.

For each stratified immigrant visa category model, we estimated effect sizes for the world region of origin interaction term by calculating the beta for immigrants and long-term residents for each world region of origin category as:

- Beta immigrant: Sum of the coefficient for immigrant (yes) + world region of Origin + immigrant (yes)*world region of origin.
- Beta long-term resident: coefficient for world region of origin

We then obtained the Hazard score for immigrants and long-term residents as exp(beta) and calculated the Hazard Ratio for each immigrants' world region of origin (Hazard [immigrants]/Hazard [long-term residents]).All analyses were conducted with SAS software, version 9.4 (SAS Institute Inc., Cary, NC).

2.3 **RESULTS**

2.3.1 Participants

Between 1992 to 2010, a total of 2,037,657 immigrants were identified from the IRRC who landed in Ontario. Of those, 1,489,484 were aged 18 to 70 years of age, and 1,402,586 were eligible residents of Ontario. Among eligible immigrants, 1,187,623 were disease-free three years after landing in Ontario. After removing immigrants with visa categories classified as "other" (2.64%) and those with complete information for matching, 1,156,122 were eligible and included in our study population.

For the long-term Ontario residents' cohort, a total of 14,155,837 individuals were identified from the RPDP who were aged 18 to 70 years of age. After removing individuals who were also present at any point in the IRCC database and keeping only those individuals whose very

first record was in Ontario, a total of 11,412,294 were retained. Among long-term residents retained, 9,815,198 were eligible residents of Ontario, and 7,606,536 were disease-free on January 1, 1995.

1,156,122 eligible long-term Ontario residents, with complete information to be matched, were randomly selected, and matched by age, sex, and RIO to each eligible, disease-free immigrant. The disease status of each long-term resident was verified in all the ICES-derived disease cohorts at the time of matching to ensure they were disease-free on December 31 three years following each immigrants' landing year.

2.3.2 Descriptive data

A total of 2,312,244 immigrants and long-term Ontario residents were included in our analysis (Table 2.1). Most of the immigrant cohort immigrated to Canada with an Economic visa category (50.8%), followed by Families (36.1%) and Refugees (13.1%). The proportion of immigrants, by age and sex, varied across immigrant categories. There was a higher proportion of female family immigrants (61.0%) compared to Refugees (45.3%) and Economic immigrants (49.6%). Over half of refugees (54.3%) and economic class immigrants (66.6%) were aged 30 to 44 years of age, compared to only 37.2% of family class immigrants.

The World region of origin accounting for the largest proportion of all immigrant categories were South Asia, followed by East Asia & the Pacific for family (27.4%) and economic class immigrants (35.6%). Sub-Saharan Africa (18.7%) and Eastern Europe and Central Asia (18.1%) accounted for the second largest proportion of refugees. Sixty percent (60.0%) of economic class immigrants had a University degree or higher upon landing, compared to only 13.4% and 23.8% of refugee and family immigrants, respectively. However, 56.2% of refugees had an education level of secondary or less compared to 49.4% and 17.0% of family and economic immigrants, respectively. Compared to long-term residents of Ontario, immigrants were more likely to live in lowest-income neighborhoods. The proportion of refugees living in the lowest income neighborhood was the

highest compared to family and economic class immigrants (51.6% vs. 31.6% and 29.7% respectively).

2.3.3 Outcome

The total follow-up period in this study was 21 years from January 1, 1995, to December 31, 2016. Among immigrants, the proportion of having any chronic condition was highest among refugees (28.0%) compared to family (25.9%), economic immigrants (21.7%) and long-term residents (24.1%) (Table 2.2).

Among those with a chronic condition, hypertension and diabetes were the most common single condition for all immigrant groups and long-term residents. The proportion of individual chronic conditions varied across immigrants and long-term residents depending on the type of condition.

Hypertension was also the most common first diagnosed chronic condition, followed by diabetes, for all immigrant categories and long-term residents. Certain conditions, such as COPD and cancer, were more commonly first diagnosed among long-term residents of Ontario (Table 2.2).

2.3.4 Unadjusted findings

Table 2.3 summarizes the unadjusted relative risk for single chronic conditions for immigrant categories compared to long-term residents. Since each long-term resident was assigned the same immigrant visa category as their matched immigrant counterpart, each immigrant visa category was only compared to long-term residents from the same category they were matched with. Refugees had a higher relative risk for developing asthma (1.31 [95% CI: 1.26 – 1.36]), hypertension (1.25 [95% CI: 1.23 – 1.27]) and diabetes (1.98 [95% CI: 1.93 – 2.03]} compared to long-term residents of Ontario. The relative risk for all other single chronic conditions were highest among refugees compared to other immigrant categories, but had a lower risk compared to long-term Ontario residents (Figure 2.1).

Table 2.4a summarizes the unadjusted relative risk of having any chronic condition for immigrant categories compared to long-term residents. Refugees had the highest overall relative risk (1.25 [95% CI: 1.24 – 1.27]) compared to long-term residents. Economic immigrants had the lowest relative risk compared to long-term Ontario residents (0.90 [95% CI: 0.90 – 0.91]). The relative risk, stratified by socio-demographic and migrant characteristics, remained highest among refugees, compared to long-term residents, as well as other immigrant categories. The relative risk was higher with older age, lower neighborhood income quintiles, lower education level upon landing, and more recent landing cohorts, across all immigrant categories.

The unadjusted relative risk varied by world regions of origin. Immigrants from the Caribbean and South Asia had the highest relative risk compared to long-term residents, irrespective of their immigration category. Rates for certain world regions varied by their immigration category. For example, refugees from North Africa and the Middle East had a higher relative risk compared to long-term residents (1.13 [95% CI: 1.08 – 1.17]); however, family [0.92 [95% CI: 0.90 – 0.96]) and economic immigrants [0.81 [95% CI: 0.79 – 0.83]), from the same world region of origin, had a lower relative risk compared to long-term residents.

2.3.5 Sensitivity analysis

We calculated the unadjusted relative risk for developing a chronic condition by excluding hypertension and diabetes from the outcome variable. When we excluded these two conditions, the relative risk was the same or lower, for all immigrant categories, compared to long-term Ontario residents (Table 2.4b). The rates did not considerably change when we estimated the relative risk across different socio-demographic and migrant characteristics.

2.3.6 Adjusted multivariate models

Table 2.5 presents the adjusted Hazard Ratios (HR) and 95% Confidence Intervals (CI) of having a chronic condition for each immigrant category compared to long-term residents using

Multivariate Cox Proportional Hazard models. After adjusting for immigrant status, age, sex and neighborhood income quintiles, refugees had the highest HR (HR: 1.19, 95% CI: 1.17 – 1.21). Family (HR: 0.97, 95% CI:0.96 – 0.98) and economic class immigrants (HR: 0.88, 95% CI: 0.87 – 0.89) had a lower risk of developing a chronic condition compared to long-term residents. The risk of having a chronic condition was higher among individuals in the older age categories compared to those 18 to 29 years of age. Women also had a lower risk compared to men. The risk of developing a chronic condition was lower with higher income quintiles compared to individuals in the lower neighborhood income quintile groups.

The risk of developing a chronic condition for immigrant categories varied by world regions of origin after adjusting for age, sex, and neighborhood income quintiles. Table 2.6 displays the adjusted HRs and 95% CI for each immigrants' world region of origin (compared to long-term residents) that were obtained after including the interaction term used the stratified multivariate models. Appendix J provides the complete multivariate model outputs with the interaction terms. Immigrants from the Caribbean and South Asia had a higher risk of developing a chronic condition, across all immigrant categories, compared to long-term residents in the adjusted models. Among refugees, individuals from sub-Saharan Africa (HR: 1.21, 95% CI: 1.17 – 1.25) and North Africa and the Middle East (HR: 1.08, 95% CI: 1.03 – 1.13) had an increased risk of developing a chronic condition compared to long-term residents (Figure 2.2). Among family class immigrants, individuals from sub-Saharan Africa had an increased risk compared to long-term residents (HR: 1.10, 95% CI: 1.05 – 1.15) (Figure 2.3). Immigrants from other world regions of origin had a lower risk of developing a chronic condition compared to long-term residents, where rates varied across different immigrant categories (Figures 2.2-2.4).

2.4 TABLES AND FIGURES

Table 2.1 Baseline characteristics of immigrants and long-term Ontario resident disease-free study populations, n (%).

	Long-term Residents		Refugees		Family Immigrants		Economic Immigrants	
Population (N)	**1,156,122**		**151,826**		**417,562**		**586,734**	
Sex								
Male	541,737	(46.9)	83,054	(54.7)	162,807	(39.0)	295,876	(50.4)
Female	614,385	(53.1)	68,772	(45.3)	254,755	(61.0)	290,858	(49.6)
Age Categories (Baseline)								
18–29	306,478	(26.5)	48,816	(32.2)	165,801	(39.7)	91,847	(15.6)
30–44	627,830	(54.3)	79,503	(52.4)	157,497	(37.2)	390,918	(66.6)
45+	221,814	(19.2)	23,507	(15.5)	94,264	(22.6)	103,969	(17.7)
Neighborhood Income quintiles								
Q1 (lowest income)	221,787	(19.2)	78,187	(51.6)	132,047	(31.6)	173,976	(29.7)
Q2	232,512	(20.1)	32,823	(21.6)	96,673	(23.2)	119,764	(20.4)
Q3	236,531	(20.5)	19,702	(13.0)	78,505	(18.8)	105,931	(18.1)
Q4	233,873	(20.2)	13,494	(8.90)	68,277	(16.4)	102,996	(17.6)
Q5	231,173	(20.0)	7,396	(4.90)	418,663	(10.0)	83,848	(14.3)
World Region of Origin								
East Asia & the Pacific	-	-	14,771	(9.8)	114,275	(27.4)	208,266	(35.6)
South Asia	-	-	39,145	(25.9)	119,574	(28.7)	146,507	(25.0)
Eastern Europe & Central Asia	-	-	27,310	(18.1)	38,257	(9.2)	84,639	(14.4)
North Africa & the Middle East	-	-	22,007	(14.6)	25,961	(6.2)	61,194	(10.4)
Latin America	-	-	16,256	(10.8)	32,269	(7.8)	20,332	(3.5)
Western Europe & US	-	-	741	(0.49)	34,152	(8.2)	31,366	(5.4)
Sub-Saharan Africa	-	-	28,244	(18.7)	18,272	(4.4)	17,683	(3.0)
Caribbean	-	-	2,651	(1.75)	33,606	(8.1)	15,672	(2.7)
Unknown			55	(<1%)	90	(<1%)	54	(<1%)
Educational Level at Landing								
Secondary or less	-	-	85,279	(56.2)	206,384	(49.4)	99,431	(17.0)
(Non-University Qualifications/Some University	-	-	46,272	(30.5)	111,970	(26.8)	134,701	(23.0)
University Degree or Higher	-	-	20,275	(13.4)	99,208	(23.8)	352,602	(60.0)
Landing Cohort (year of arrival)	-	-						
1992–1995	-	-	42,361	(27.9)	115,255	(27.6)	102,021	(17.4)

Table 2.1 Baseline characteristics of immigrants and long-term Ontario resident disease-free study populations, n (%).

	Long-term Residents		Refugees		Family Immigrants		Economic Immigrants	
1996–1999	-	-	24,509	(16.1)	70,173	(16.8)	118,446	(20.2)
2000–2003	-	-	28,007	(18.4)	85,282	(20.4)	160,079	(27.3)
2004–2007	-	-	38,091	(25.1)	88,981	(21.3)	122,688	(20.9)
2008–2010	-	-	18,858	(12.4)	57,871	(13.9)	83,500	(14.2)
Language Proficiency at Landing								
English, French or both	-	-	105,378	(69.4)	243,714	(58.4)	462,377	(78.8)
None	-	-	46,442	(30.6)	173,842	(41.6)	124,351	(21.2)

Table 2.2 Prevalence of developing any chronic condition, individual chronic conditions, and type of first disease diagnosis among immigrants and long-term residents from 1995-2016 (n, %).

	LONG-TERM RESIDENTS		REFUGEES		FAMILY		ECONOMIC	
Population (N)	**1,156,122**		**151,826**		**417,562**		**586,734**	
ANY CHRONIC CONDITION *								
Yes	278,831	(24.1)	42,494	(28.0)	108,088	(25.9)	127,406	(21.7)
No	877,291	(75.9)	109,332	(72.0)	309,474	(74.1)	459,328	(78.3)
INDIVIDUAL CHRONIC CONDITIONS-†								
Hypertension	162,452	(58.3)	24,723	(58.2)	69,063	(63.9)	78,996	(62.0)
Diabetes	66,580	(23.9)	16,313	(38.4)	38,124	(35.3)	43,915	(34.5)
Asthma	40,450	(14.5)	6,986	(16.4)	17,585	(16.3)	15,951	(12.5)
COPD	55,922	(20.1)	5,221	(12.3)	11,096	(10.3)	11,350	(8.9)
Cancer	29,176	(10.5)	2,354	(5.5)	7,890	(7.3)	8,368	(6.6)
CHF	10,991	(3.9)	923	(2.2)	3,627	(3.4)	2,060	(1.6)
MI	8,946	(3.2)	988	(2.3)	2,087	(1.9)	2,436	(1.9)
RA	5,864	(2.1)	736	(1.7)	1,961	(1.8)	1,834	(1.4)
CCC	3,748	(0.4)	242	(0.6)	603	(0.6)	785	(0.6)
FIRST DISEASE DIAGNOSIS-‡								
Hypertension	133,159	(47.8)	19,425	(45.7)	55,724	(51.6)	66,692	(52.4)
Diabetes	40,911	(14.7)	11,056	(26.0)	23,968	(22.2)	30,199	(23.7)
Asthma	32,475	(11.6)	5,593	(13.2)	13,792	(12.8)	12,798	(10.0)
COPD	37,433	(13.4)	3,435	(8.1)	6,221	(5.8)	7,808	(6.1)
Cancer	19,780	(7.1)	1,591	(3.7)	4,865	(4.5)	6,145	(4.8)
RA	4,071	(1.5)	488	(1.2)	1,354	(1.2)	1,332	(1.0)
MI	4,112	(1.5)	402	(1.0)	714	(0.7)	1,038	(0.8)
CHF	3,780	(1.4)	307	(0.7)	956	(0.9)	738	(0.6)
CCC	3,110	(1.1)	197	(0.5)	494	(0.5)	656	(0.5)

* Presence of at least 1 of the 9 chronic conditions from ICES derived disease cohorts

† Among those who have a diagnosed chronic condition

‡ Frequency of a chronic condition to be first diagnosed based on ICES derived disease cohorts

Table 2.3 Unadjusted relative risk (RR) and 95% Confidence Intervals (C.I) of individual chronic conditions for immigrant categories compared to long-term residents per 1000 person-years follow up, 1995-2016.

	REFUGEE		FAMILY		ECONOMIC	
INDIVIDUAL CHRONIC CONDITIONS						
Asthma	1.31	(1.26–1.36)	1.09	(1.07–1.11)	0.83	(0.81–0.85)
CHF	0.87	(0.79–0.95)	0.61	(0.58–0.64)	0.51	(0.48–0.54)
COPD	0.75	(0.72–0.78)	0.52	(0.51–0.53)	0.40	(0.39–0.41)
Hypertension	1.25	(1.23–1.27)	1.09	(1.08–1.10)	0.99	(0.98–1.00)
CCC	0.45	(0.38–0.52)	0.42	(0.38–0.46)	0.43	(0.40–0.46)
Cancer	0.75	(0.71–0.79)	0.57	(0.55–0.59)	0.66	(0.65–0.67)
Diabetes	1.98	(1.93–2.03)	1.57	(1.54–1.60)	1.33	(1.32–1.34)
MI	0.88	(0.80–0.96)	0.59	(0.56–0.62)	0.56	(0.53–0.59)
RA	1.03	(0.91–1.15)	0.82	(0.77–0.87)	0.65	(0.61–0.69)

Figure 2.1 Unadjusted Relative Risk of Individual Chronic Conditions, for Immigrant Categories, compared to long-term Residents per 1000 person-years follow-up.

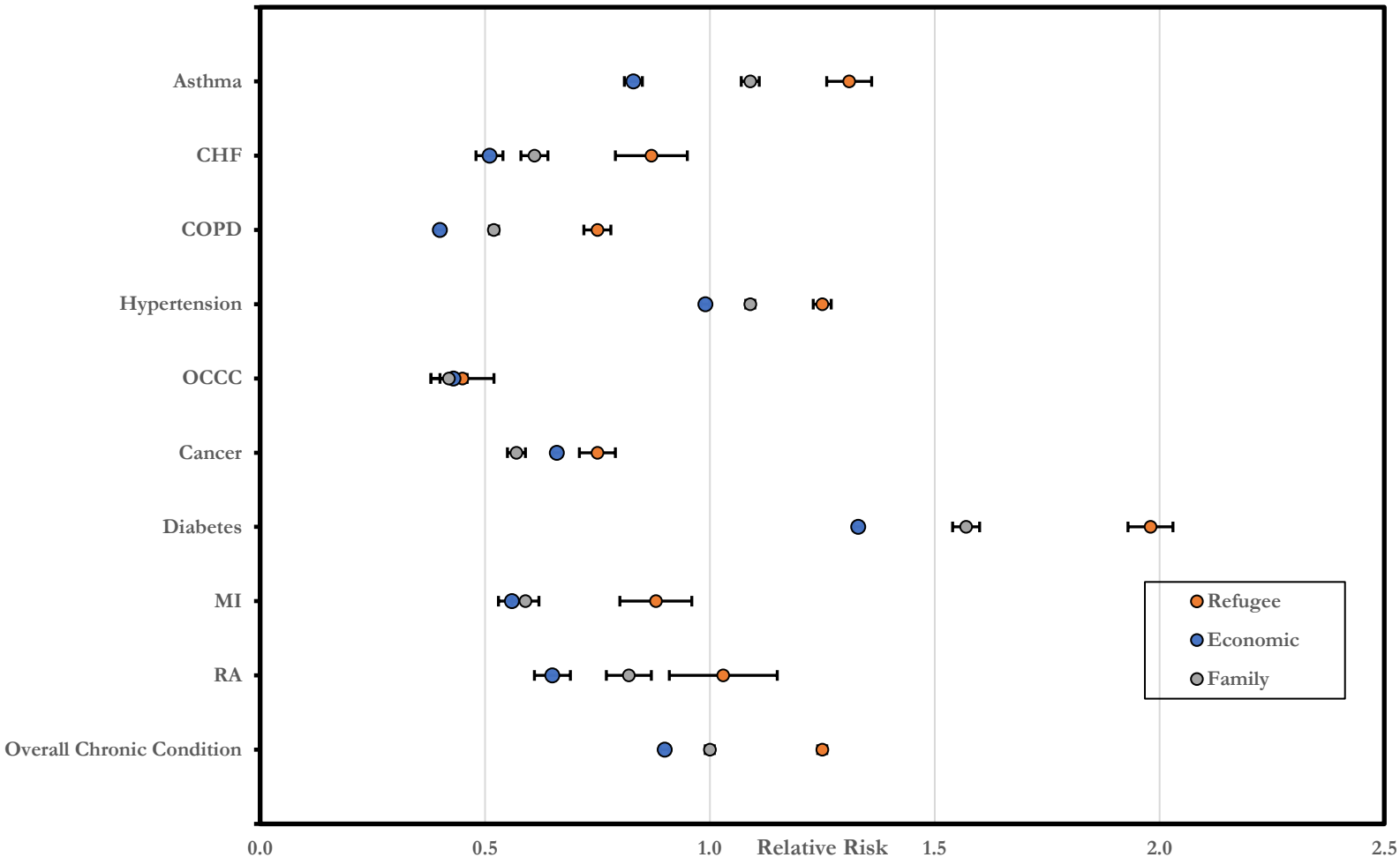


Table 2.4a Unadjusted relative risk (RR) and 95% Confidence Intervals (C.I) of developing any chronic condition for immigrant categories compared to long-term residents per 1000 person–years follow up, 1995–2016.

	REFUGEE	FAMILY	ECONOMIC
OVERALL	1.25 (1.24–1.26)	1.00 (0.99–1.01)	0.90 (0.89–0.91)
SEX			
Males	1.24 (1.22–1.26)	1.04 (1.03–1.05)	0.90 (0.89–0.91)
Females	1.28 (1.25–1.31)	1.01 (1.00–1.02)	0.91 (0.90–0.92)
AGE CATEGORY (BASELINE)			
18–29	1.23 (1.19–1.27)	1.19 (1.17–1.21)	0.88 (0.86–0.90)
30–44	1.27 (1.23–1.29)	1.10 (1.08–1.12)	0.92 (0.91–0.93)
45+	1.30 (1.26–1.34)	0.87 (0.86–0.88)	0.86 (0.85–0.87)
NEIGHBORHOOD INCOME QUINTILES (BASELINE)			
Q1 (lowest income)	1.31 (1.28–1.34)	1.15 (1.13–1.17)	1.01 (1.00–1.03)
Q2	1.26 (1.22–1.30)	1.03 (1.02–1.04)	0.94 (0.92–0.96)
Q3	1.23 (1.19–1.27)	0.98 (0.96–1.00)	0.89 (0.88–0.90)
Q4	1.15 (1.09–1.21)	0.90 (0.88–0.92)	0.84 (0.83–0.85)
Q5	1.09 (1.02–1.16)	0.75 (0.73–0.77)	0.72 (0.70–0.74)
EDUCATIONAL LEVEL AT LANDING			
Secondary or less	1.34 (1.31–1.37)	1.05 (1.04–1.06)	0.98 (0.96–1.00)
Non–University Qualifications/ Some University	1.19 (1.16–1.22)	1.01 (0.99–1.03)	0.93 (0.92–0.94)
University Degree or Higher	1.09 (1.05–1.13)	0.95 (0.93–0.97)	0.87 (0.86–0.88)
WORLD REGION OF ORIGIN			
Caribbean	1.26 (1.08–1.44)	1.29 (1.25–1.33)	1.33 (1.28–1.38)
East Asia & the Pacific	1.02 (0.97–1.07)	0.83 (0.82–0.84)	0.78 (0.77–0.79)
Eastern Europe & Central Asia	0.98 (0.95–1.01)	0.85 (0.83–0.87)	0.82 (0.81–0.83)
Latin America	0.97 (0.92–1.02)	1.07 (1.04–1.10)	0.83 (0.80–0.86)
North Africa & the Middle East	1.13 (1.08–1.18)	0.92 (0.90–0.94)	0.81 (0.79–0.83)
South Asia	1.78 (1.74–1.82)	1.33 (1.31–1.35)	1.27 (1.25–1.29)
Sub–Saharan Africa	1.29 (1.24–1.34)	1.18 (1.13–1.23)	1.01 (0.97–1.05)
Western Europe & US	1.15 (0.87–1.43)	0.72 (0.69–0.75)	0.61 (0.59–0.63)
Unknown	1.26 (1.08–1.44)	1.29 (1.25–1.33)	1.33 (1.28–1.38)
LANGUAGE PROFICIENCY ON LANDING			
None	1.19 (1.16–1.22)	0.99 (0.98–1.00)	0.80 (0.79–0.81)
English, French, or Both	1.29 (1.26–1.33)	1.05 (1.04–1.06)	0.94 (0.93–0.95)
LANDING COHORT (YEAR OF ARRIVAL)			
1992–1995	1.16 (1.13 –1.19)	0.94 (0.93–0.95)	0.86 (0.85–0.87)
1996–1999	1.24 (1.20–1.28)	1.02 (1.00–1.04)	0.82 (0.81–0.83)
2000–2003	1.38 (1.33–1.43)	1.09 (1.07–1.11)	0.91 (0.89–0.93)
2004–2007	1.38 (1.33–1.43)	1.17 (1.14–1.20)	1.08 (1.06–1.10)
2008–2010	1.65 (1.50–1.80)	1.32 (1.25–1.39)	1.36 (1.31–1.41)

Table 2.4b Unadjusted relative risk (RR) and 95% Confidence Intervals (C.I) of developing any chronic condition (excluding hypertension and diabetes) for immigrants categories, compared to long-term residents per 1000 person–years follow up, 1995–2016.

	REFUGEE	FAMILY	ECONOMIC
OVERALL	0.99 (0.98–1.00)	0.97 (0.96–0.98)	0.98 (0.97–0.99)
SEX			
Males	0.99 (0.98–1.00)	0.97 (0.96–0.98)	0.97 (0.96–0.98)
Females	1.00 (0.99–1.01)	0.97 (0.96–0.98)	0.98 (0.97–0.99)
AGE CATEGORY (BASELINE)			
18–29	1.00 (0.99–1.01)	0.97 (0.96–0.98)	0.96 (0.95–0.97)
30–44	0.99 (0.98–1.00)	0.99 (0.98–1.00)	0.97 (0.96–0.98)
45+	0.97 (0.96–0.98)	0.94 (0.93–0.95)	0.96 (0.95–0.97)
NEIGHBORHOOD INCOME QUINTILES (BASELINE)			
Q1 (lowest income)	0.99 (0.98–1.00)	0.96 (0.95–0.97)	0.96 (0.95–0.97)
Q2	0.99 (0.97–1.01)	0.97 (0.96–0.98)	0.97 (0.96–0.98)
Q3	1.01 (0.99–1.03)	0.97 (0.95–0.99)	0.98 (0.97–0.99)
Q4	0.97 (0.94–1.00)	0.98 (0.97–0.99)	0.98 (0.97–0.99)
Q5	0.99 (0.96–1.02)	0.99 (0.98–1.00)	1.00 (0.99–1.01)
EDUCATIONAL LEVEL AT LANDING			
Secondary or less	1.00 (0.99–1.01)	0.96 (0.95–0.97)	0.99 (0.98–1.00)
Non–University Qualifications/ Some University	0.99 (0.98–1.00)	0.98 (0.97–0.99)	0.98 (0.97–0.99)
University Degree or Higher	0.99 (0.98–1.00)	0.97 (0.95–0.99)	0.95 (0.94–0.97)
WORLD REGION OF ORIGIN			
Caribbean	0.97 (0.92–1.03)	0.93 (0.92–0.94)	0.93 (0.92–0.95)
East Asia & the Pacific	1.01 (0.98–1.03)	0.99 (0.98–0.99)	0.98 (0.98–0.99)
Eastern Europe & Central Asia	0.96 (0.95–0.98)	0.94 (0.93–0.96)	0.93 (0.93–0.96)
Latin America	0.95 (0.93–0.97)	0.94 (0.93–0.96)	0.97 (0.95–0.99)
North Africa & the Middle East	1.02 (1.00–1.04)	1.02 (1.00–1.04)	1.02 (1.01–1.03)
South Asia	0.97 (0.96–0.98)	0.96 (0.95–0.97)	0.97 (0.96–0.98)
Sub–Saharan Africa	1.07 (1.05–1.09)	0.98 (0.96–1.00)	1.01 (0.99–1.03)
Western Europe & US	1.04 (0.94–1.16)	1.02 (1.01–1.04)	1.05 (1.03–1.07)
LANGUAGE PROFICIENCY ON LANDING			
None	1.00 (0.99–1.01)	0.98 (0.97–0.99)	0.98 (0.97–0.99)
English, French, or Both	0.98 (0.97–0.99)	0.95 (0.94–0.96)	0.96 (0.95–0.97)
LANDING COHORT			
1992–1995	1.02 (1.01–1.03)	1.02 (1.01–1.03)	1.07 (1.06–1.08)
1996–1999	0.95 (0.93–0.97)	0.89 (0.88–0.90)	0.89 (0.88–0.90)
2000–2003	0.96 (0.94–0.98)	0.91 (0.90–0.92)	0.91 (0.90–0.92)
2004–2007	0.99 (0.98–1.00)	0.97 (0.96–0.98)	0.98 (0.97–0.99)
2008–2010	0.99 (0.98–1.00)	0.98 (0.97–0.99)	0.99 (0.98 –1.00)

Table 2.5 Adjusted Hazard Ratios (HR) and 95% Confidence Intervals (C.I) of developing any chronic condition, 1995-2016, for immigrant categories, compared to Long-term Residents of Ontario: results of multivariate regression analyses.

	REFUGEE		FAMILY		ECONOMIC	
Population (N)	**151,698**		**417,422**		**586,560**	
IMMIGRANT (YES)	1.19	(1.17–1.21)	0.97	(0.96–0.98)	0.88	(0.87–0.89)
AGE CATEGORY						
18–29 (reference)	—	—	—	—	—	—
30–49	2.02	(1.98–2.06)	1.79	(1.77–1.81)	2.02	(1.99–2.05)
50+	4.30	(4.21–4.39)	5.16	(5.10–5.22)	3.96	(3.90–4.02)
SEX						
Female	0.94	(0.92–0.96)	0.90	(0.89–0.91)	0.91	(0.90–0.92)
Male (reference)	—	—	—	—	—	—
NEIGHBORHOOD INCOME QUINTILES						
Q1 (lowest income)	1.28	(1.24–1.32)	1.37	(1.35–1.39)	1.31	(1.30–1.32)
Q2	1.22	(1.18–1.26)	1.26	(1.24–1.28)	1.24	(1.23–1.25)
Q3	1.14	(1.10–1.18)	1.20	(1.18–1.22)	1.19	(1.17–1.21)
Q4	1.09	(1.06–1.12)	1.11	(1.10–1.12)	1.13	(1.11–1.15)
Q5 (reference)	—	—	—	—	—	—

*The N size of long-term residents is equal to the N displayed for each immigrant category.

Table 2.6 Adjusted Hazard Ratios (HR) and 95% Confidence Intervals (C.I) of developing a chronic condition for Immigrant Categories compared to long-term residents by World Region of Origin, 1995-2016.

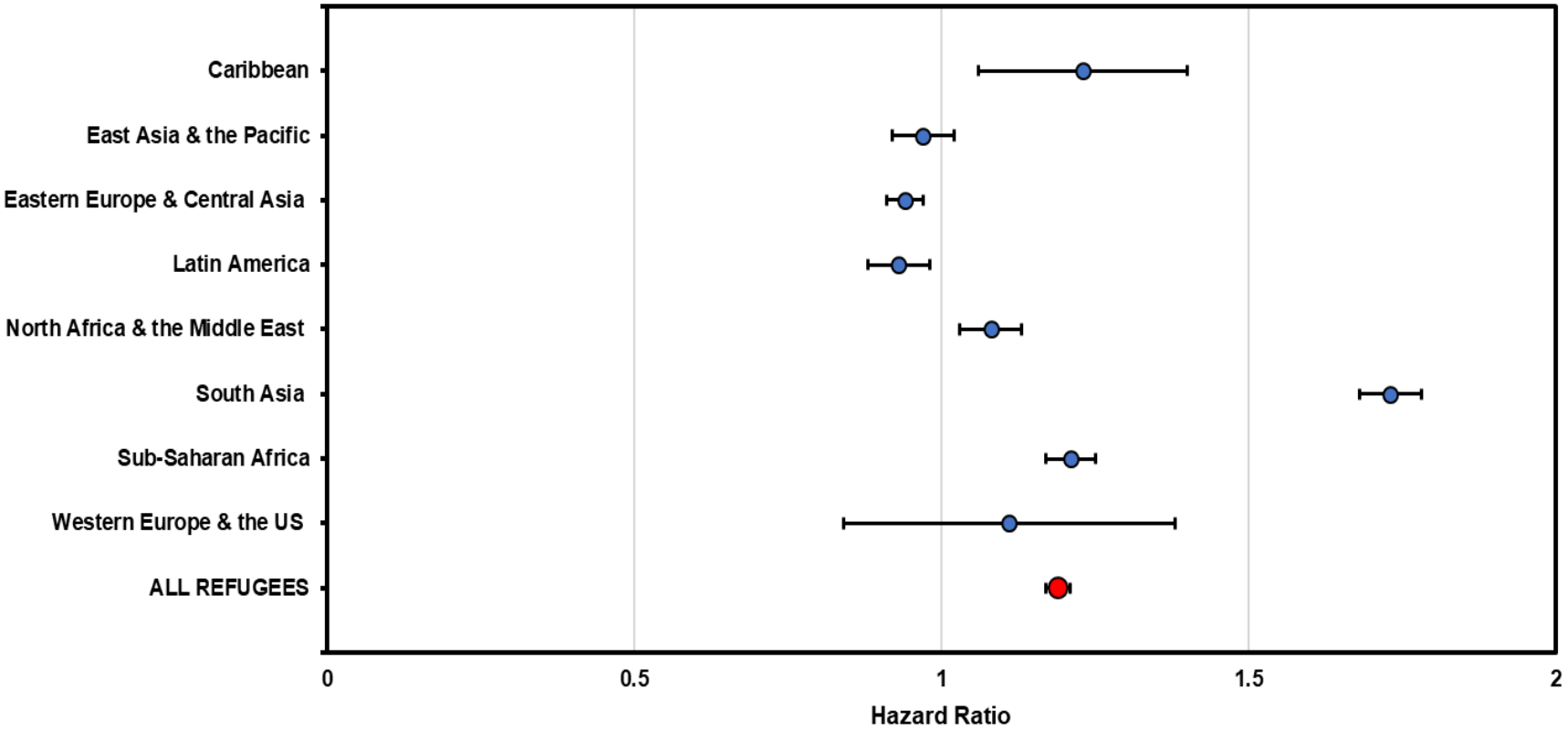
IMMIGRANT CATEGORIES World Region of Origin	Hazard Ratios	95% Confidence Intervals
REFUGEES N= 151,053		
Caribbean	1.23	1.06—1.40
East Asia & the Pacific	0.97	0.92—1.02
Eastern Europe & Central Asia	0.94	0.91—0.97
Latin America	0.93	0.88—0.98
North Africa & the Middle East	1.08	1.03—1.13
South Asia	1.73	1.68—1.78
Sub-Saharan Africa	1.21	1.17—1.25
Western Europe & the US	1.11	0.84—1.38
FAMILY N= 416,317		
Caribbean	1.23	1.19—1.27
East Asia & the Pacific	0.78	0.77—0.79
Eastern Europe & Central Asia	0.82	0.80—0.84
Latin America	1.03	0.99—1.07
North Africa & the Middle East	0.88	0.85—0.91
South Asia	1.29	1.27—1.31
Sub-Saharan Africa	1.10	1.05—1.15
Western Europe & the US	0.71	0.68—0.74
ECONOMIC N= 585,539		
Caribbean	1.30	1.25—1.35
East Asia & the Pacific	0.76	0.75—0.77
Eastern Europe & Central Asia	0.80	0.79—0.81
Latin America	0.82	0.78—0.86
North Africa & the Middle East	0.80	0.78—0.82
South Asia	1.23	1.21—1.25
Sub-Saharan Africa	1.00	0.96—1.04
Western Europe & the US	0.61	0.59—0.63

[*] Adjusted HR of immigrant status*world region of origin interaction term obtained from the stratified multivariate models. These HRs are adjusted by age, sex, and neighborhood-level income quintiles.

* The immigrant*world region of origin interaction term compared immigrants to long-term Ontario residents. The reference category is the long-term Ontario residents when comparing the effect immigration within each immigrants' world region of origin.

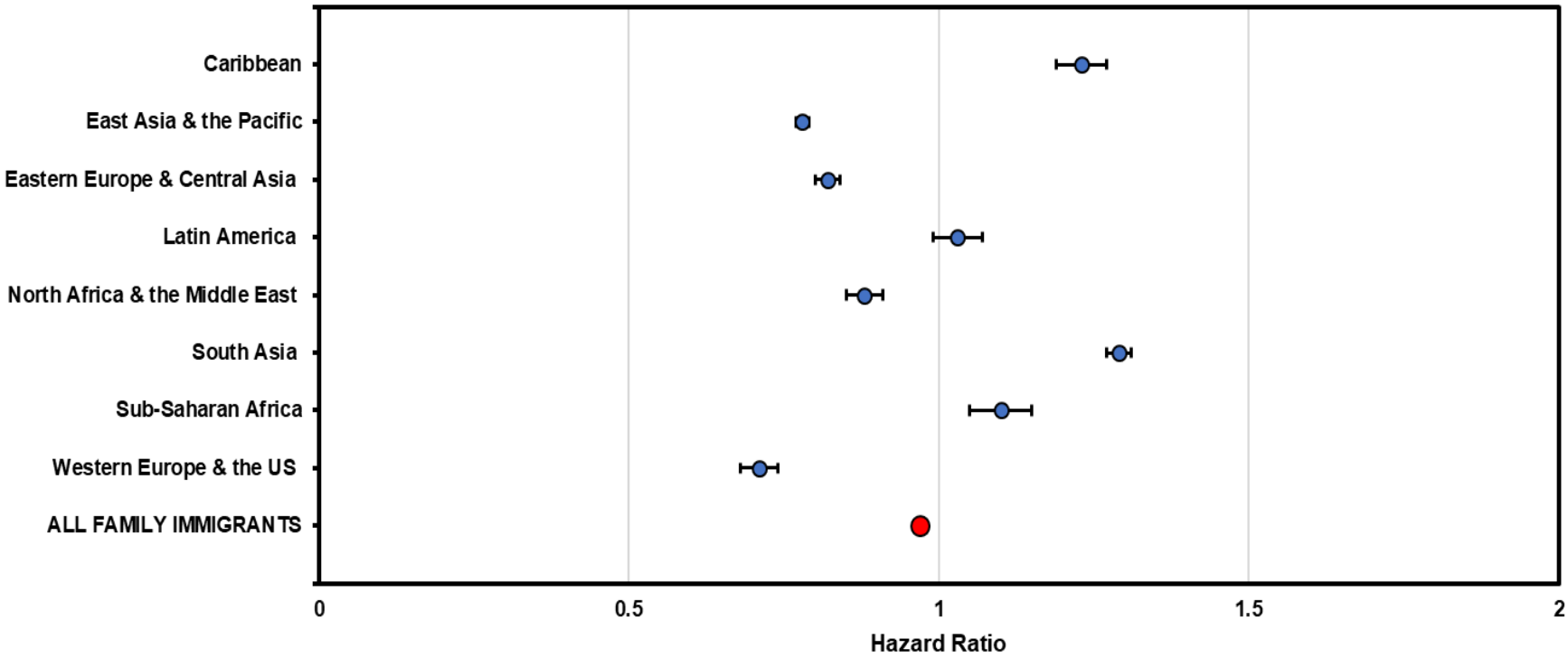
*The N size of long-term residents is equal to the N displayed for each immigrant category.

Figure 2.2 Adjusted Hazard Ratios for Refugees, by World Regions of Origin, compared to Long-term Residents of Ontario.



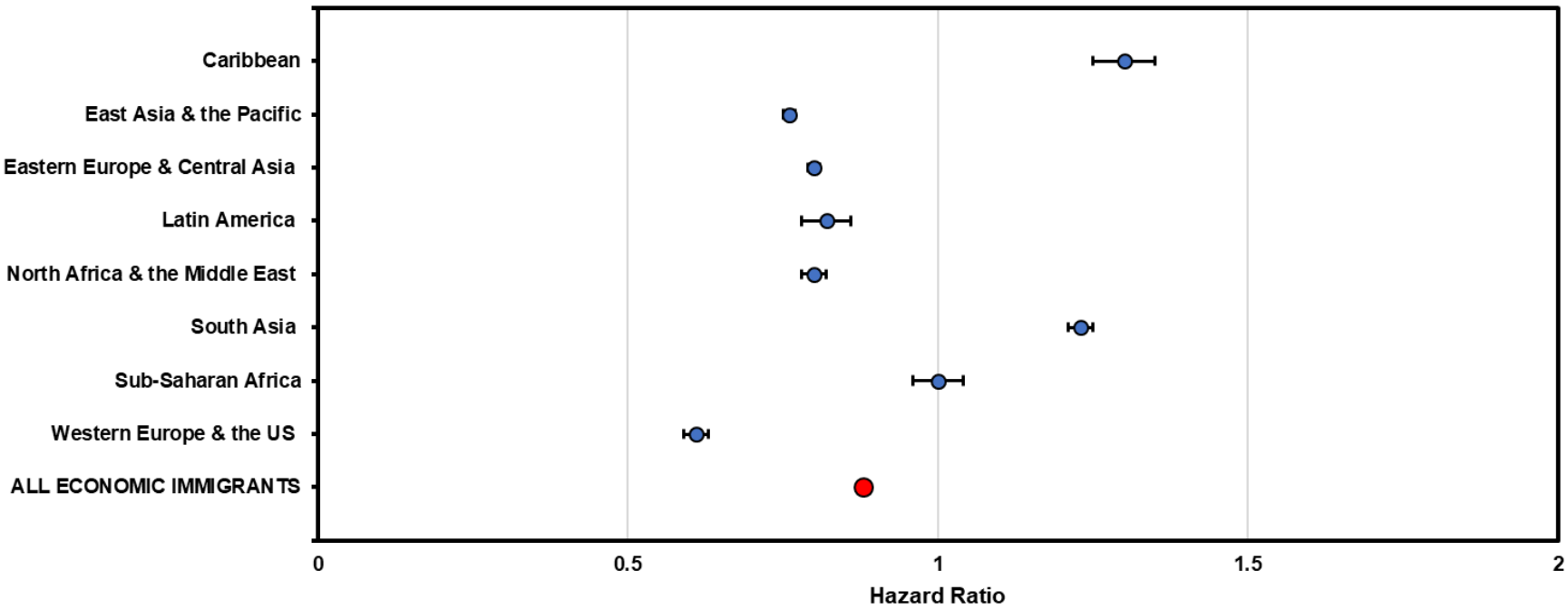
Adjusted by immigrant status*world region of origin interaction term, age, sex and neighborhood income

Figure 2.3 Adjusted Hazard Ratios for Family Immigrants, by World Regions of Origin, compared to Long-term Residents of Ontario.



Adjusted by immigrant status*world region of origin interaction term, age, sex and neighborhood income

Figure 2.4 Adjusted Hazard Ratios for Economic Immigrants, by World Regions of Origin, compared to Long-term Residents of Ontario.



Adjusted by immigrant status*world region of origin interaction term, age, sex and neighborhood income

2.5 DISCUSSION

2.5.1 Main Findings

In this study we found that the risk of developing a chronic condition varied by the type of chronic conditions included in our analysis, an immigrants' visa category, world regions of origin and neighborhood level income.

Type of Chronic Conditions

Individually, we observed a higher unadjusted risk in diabetes, for all immigrant categories, compared to long-term residents of Ontario. We also observed an elevated unadjusted risk in hypertension and asthma incidence for refugee and family class immigrants when compared to long-term residents. These findings are consistent with previous literature that have reported higher rates of diabetes in immigrant populations (Creatore, 2013; Creatore et al., 2010), greater risk in hypertension and various respiratory illnesses across different immigrant groups (Beiser & Hou, 2014; Eric I Benchimol et al., 2015; Creatore, 2013; Creatore et al., 2010; Fernandez, Davidson, Miranda, Everett, & Salamonson, 2014; Gholap, Davies, Patel, Sattar, & Khunti, 2011; Norredam et al., 2014; M. Patel, Phillips-Caesar, & Boutin-Foster, 2014; Reed & Barbosa, 2017; Rosella, Manuel, Burchill, & Stukel, 2011; Siddiqi et al., 2016)

Norredam and colleagues (2014) investigated the incidence of several disease occurrences among migrants in Denmark over time, and found that the risk of stroke and breast cancer was lower, but increased with longer follow-up time for refugees and family immigrants, whereas rates for ischaemic heart disease and diabetes were higher among refugees and family-reunification immigrants compared to native-born individuals during the entire study period (Norredam et al., 2014).

In Canada, a cross-sectional study by Beiser and Hou (2014) examined chronic health conditions, labour market participation and resource consumption among immigrants and Canadian-

born residents using data from the Canadian Community Health Survey (CCHS). They reported that immigrants, overall, had better self-reported health than Canadian-born individuals, irrespective of their length of stay in Canada. Thirty-one (31.7%) of recent immigrants reported having at least one physical condition compared to 55% of long-term immigrants and 51.1% of Canadian-born individuals. With the exception of diabetes, high blood pressure and gastro-intestinal ulcers, immigrants had less odds of reporting at least one physical condition than Canadian-born individuals, after controlling for age and sex (Beiser & Hou, 2014). Although this cross-sectional study did not account for differences among immigrant categories and world regions of origin, these findings are consistent with our results when we consider that all immigrants had a higher risk for certain individual conditions, such as diabetes, and had an overall lower risk of developing any chronic condition when excluding hypertension and diabetes from our outcome measure.

Kennedy and colleagues (2015) examined the healthy immigrant effect, using physical health and health behaviour indicators, by pooling national cross-sectional data from the USA, Canada, UK, and Australia. They reported a healthy immigrant effect among all immigrants, across different world regions, in each destination country (Kennedy, Kidd, McDonald, & Biddle, 2015). Despite variation in immigration policies, immigrants in all four countries were less likely to have a chronic condition and less likely to smoke and be obese, compared to non-immigrants (Kennedy et al., 2015).

When we excluded hypertension and diabetes from our outcome measure, our analyses showed that all immigrant categories had lower or similar unadjusted risk of developing a chronic condition compared to long-term residents. The higher rates of diabetes and hypertension across all immigrant categories observed in our study suggest that these conditions may be drivers of increased morbidity risk among immigrant populations. The literature has reported hypertension and diabetes as two of the leading risk factors for atherosclerosis, including heart attacks and stroke (Cheung and

Li, 2012). A 2018 systematic review examined this association and found hypertension and diabetes to be predictive risk factors for these chronic conditions (Alloubani, Saleh and Abdelhafiz, 2018). Additionally, there is a strong association between hypertension and diabetes with lifestyle and behavioral factors such as smoking and physical inactivity that impact rates disease incidence and prevalence in the population (Alter et al., 2012).

A common pathophysiology between diabetes and several other chronic conditions is chronic inflammation. Genetic factors, as well as obesity and physical activity, are further implicated. For example, some studies have investigated the relationship between the risk of pulmonary conditions and diabetes, by evaluating and comparing the incidence of asthma, COPD and other conditions in patients with and without diabetes (Ehrlich et al., 2010; Kornum et al., 2008; Koskinen et al., 1998; Pozzilli & Leslie, 1004). In California, a retrospective, longitudinal cohort study examined this relationship and reported that patients with diabetes had an increased risk of several pulmonary conditions such as asthma and COPD after controlling for factors such as age sex, race/ethnicity, smoking, BMI, education, alcohol consumption and outpatient visits (Ehrlich et al., 2010).

Other studies have investigated the relationship between diabetes and musculoskeletal conditions such as rheumatoid arthritis, osteoporosis, and osteoarthritis (Rehling et al., 2019; Pai et al., 2015). Rehling and colleagues (2019) investigated the relationship between diabetes and osteoarthritis, osteoporosis and rheumatoid arthritis using 2013 data from the Danish National Health survey for adults aged 40 years of age and older. After controlling for risk factors such as age, sex, BMI, individuals with diabetes had a 33 percent greater risk to have osteoarthritis, 70 % risk of rheumatoid arthritis and 29% more likely to have osteoporosis (Rehling et al., 2019). In Taiwan, investigators examined the 10-year cumulative incidence of musculoskeletal pain, the mean number of doctor visits for musculoskeletal pain, and the mean number of doctor visits for musculoskeletal

pain among individuals with type 2 diabetes, compared with those without diabetes using population-based retrospective cohort data (Pai et al., 2015). They reported that individuals with type 2 diabetes aged 18–50 years had a higher 10-year cumulative incidence of and a higher mean number of doctor visits for musculoskeletal pain than the non-diabetic group (Pai et al., 2015).

Risk by Immigrant Categories

Our multivariate analyses showed that refugees had the highest risk of developing a chronic condition, whereas family immigrants showed no differences, and economic immigrants had a lower risk compared to long-term Ontario residents. Previous research has found that the healthy immigrant effect is not always apparent when examining health outcomes across different demographic groups of immigrants (Gee, Kobayashi, & Prus, 2004; Kobayashi & Prus, 2012).In our study, the elevated risk among refugees is supported by existing evidence in the literature, where refugees have an initial health disadvantage compared to native-born and other immigrant populations (DesMeules et al., 2005; Beiser, 2005). In the US, a study examined the relationship between immigration status on self-reported health, diagnosed chronic diseases and functional limitation comparing refugees with non-refugee immigrants using the New Immigrant Survey, a nationally representative, multicohort longitudinal study of immigrants and their children (Reed & Barbosa, 2017). Refugees were more likely to report poor health status (OR=2.39, 95% CI: 1.78 – 3.21), more likely to have at least one of the six chronic health conditions examined (OR=1.88, 95% CI: 1.44 – 2.47) and having a functional limitation (OR=2.48, 95% CI: 1.89 – 3.25) compared to non-refugee immigrants. Individually, they reported a higher proportion of diagnosed hypertension, stroke, chronic lung disease, and diabetes (Reed & Barbosa, 2017), results that are similar to findings in our study.

Health disparities in mortality patterns, between refugees and non-refugee immigrants, have also been documented in previous studies (DesMeules et al., 2005; A.-C. Hollander et al.,

2012). Refugees have greater health risks both prior to and post-settlement in a host country. They are forcefully driven out of their country of origin, as opposed to other immigrant groups, who voluntarily, and often times willingly, migrate into their host country (Bo, Zinckernagel, Krasnik, Petersen, & Norredam, 2015). Prior to resettlement, many refugees spend a substantial amount of time in camps or in a temporary country where limited amounts of social and health resources are available; leading to several chronic health problems with long-term consequences during resettlement (Hyman, 2010; Beiser, 2005). Several post-settlement factors can also impact refugees' health status and outcomes. For example, a qualitative study on resettled refugees in the United States found that access to health care services, language barriers and acculturation increased stress and isolation; contributing to greater stress, barriers to seeking care, and poorer health outcomes (Morris, Popper, Rodwell, Brodine, & Brouwer, 2009).

A historical prospective study in Denmark examined an immigrants' visa category, as a determinant for morbidity, among migrants, compared with Native Danes, using register-based data (Norredam, 2015). Refugees had a higher risk of morbidity for several health problems, compared to family reunification immigrants, who had lower or similar risk to native-born Danes. Health inequalities were more pronounced among refugees, who had higher risk compared with native Danes and benefitted less from the protective factors of being a migrant compared to family reunification immigrants (Norredam, 2015).

In another study, Byberg and colleagues (2016) examined the incidence and survival of several cardiovascular diseases among immigrants and found that refugees were more disadvantaged, whereas family-reunification immigrants had lower incidences of all cardiovascular diseases studied compared to native-born Danes (Byberg et al., 2016).

Risk by World Regions of Origin

In our stratified multivariate analyses, we found that the differences in risk, by world regions of origin, varied across immigrant categories. Immigrants from the Caribbean and South Asia had an elevated risk of developing a chronic condition, across all immigrant categories, compared to long-term residents. Other world regions of origin exhibited a protective factor and had a lower risk compared to long-term residents of Ontario (e.g., Eastern Europe and Central Asia).

We also observed differences in risk, within the same world regions of origin, across different immigrant categories (Figures 2.2-2.4). Refugees from North Africa and the Middle East had an elevated risk of developing a chronic condition; however, family, and economic immigrants from the same world region of origin, had 12 to 20% lower risk compared to long-term residents respectively. Similarly, refugee and family class immigrants from sub-Saharan Africa had a higher risk of developing a major chronic condition, unlike economic immigrants from the same region who showed no differences in risk compared to their long-term resident counterparts. These findings demonstrate the importance of the entire migration process – both pre- and post-migration in overall disease risk, particularly how individuals migrated to Canada, the impact of their world region of origin and the risk for developing a chronic condition.

The country of birth or world regions of origin have previously been used as a proxy for ethnicity, which is considered as a non-modifiable risk factor associated with developing a chronic condition (Creatore, 2013; Dassanayake et al., 2009; Hempler et al., 2011; Bo et al., 2015). A systematic review in Australia examined whether being an immigrant was considered a risk factor in the prevalence of cardiovascular disease. Findings from the systematic review revealed an interacting effect between migrant status and an individual's region of origin as a risk factor. Immigrants from

the Middle East, South Asia and some European countries had higher prevalence of cardiovascular disease compared to immigrant originating from other regions (Dassanayake et al., 2009).

In Denmark, Hempler and colleagues (2011) examined the incidence of cardiovascular disease (CVD), acute myocardial infarction (AMI) and potential differences between native born Danes and immigrants born in Turkey, Pakistan and Former Yugoslavia using population-based data registries (Hempler et al., 2011). The incidence of CVD and AMI varied by country of birth. Immigrants born in Pakistan and Turkey had higher risk of AMI and CVD, whereas those born in Former Yugoslavia had similar rates of CVD compared to native-born Danes (Hempler et al., 2011).

A historical prospective cohort study on coronary heart disease (CHD) incidence found that immigrants from the Middle East, North Africa, Eastern Europe, Central Asia, and South Asia had higher incidences of CHD (Bo et al., 2015). Refugees had higher incidence than family-reunited immigrants (Bo et al., 2015).

These findings, including results from our study, highlight the importance of examining immigrant categories separately, both by their category of visa entry and by country and/or region of birth, to better understand how differences in migration patterns affect the incidence and risk of developing various chronic conditions (Hempler et al., 2011).

Impact of income

In our study, we observed a clear gradient with income. The higher the neighborhood income quintile group an individual belonged to, the lower the risk of developing a chronic condition. A literature review on the causal relationship between income inequality and health found strong evidence that large income differences have negative and damaging effects on health social well-being in the population (Pickett & Wilkinson, 2015). In 2009, Lee, Chiu, Manuel, and colleagues examined trends in risk factors for cardiovascular disease in Canada, and the impact of socio-economic status on these risk factors using multiple cycles of the National Population Health Survey

and the CCHS data. During the study period, hypertension, diabetes, and obesity increased significantly in the lowest income category (Lee et al., 2009).

In 2013, a Canadian study examined self-reported health at a regional and neighborhood scale using data from the CCHS and the Canadian Marginalization Index to compare Canadian-born, all immigrant populations and Chinese immigrants (Wang & Hu, 2013). Findings from this study found varying degrees of association between self-reported health, neighborhood material deprivation and ethnic concentration in census tracts (Wang & Hu, 2013). There were significant area inequalities across Census Metropolitan areas in risk of reporting unhealthy status, with a greater effect in the immigrant population. Neighborhood deprivation moderately increased the likelihood of reporting poor health for all groups, with negative effects of ethnic concentration on self-rated health (Wang & Hu, 2013).

2.5.2 Strengths and Limitations of the Study

This study overcame several methodological challenges. We followed a healthy cohort of immigrants and long-term residents of Ontario forward to examine the risk of developing a chronic condition, with the ability to distinguish whether the chronic condition was present before or after immigration into the destination country. Our healthy cohort of immigrants were disease-free three years after landing in Canada and were matched to a disease-free long-term resident of Ontario.

We had a unique opportunity to examine outcomes among a heterogeneous immigrant population, from different world regions of origin, immigration visa categories and diverse sociodemographic profiles. A detailed profile of risk patterns across all immigrant categories and world regions of origin, on several population-based chronic health conditions, has previously been lacking in Canada. Studies have either investigated the relationship between ethnicity and health (Stevenson et al., 2018; Deb et al., 2016; Ginsburg et al., 2015; Mukerji, Chiu, Shah, 2012; Shah et al, 2010; Rosella et al., 2012) the association between migration, health and ethnicity treating

'immigrants' as a homogeneous group (Di Giuseppe et al., 2019; Iqbal et al., 2017; Tu et al., 2015; Creatore, 2010) or used cross-sectional or survey data that either lacked sufficient sample sizes or unable to establish a causal relationship due to limitations in study design (Beiser and Hou, 2014; Reed & Barbosa, 2017). This study overcame previous methodological challenges, with the ability to conduct stratified analyses by migration profile, with a large sample of immigrants representing both major world regions and immigration categories, using a longitudinal study design over a 20-year period.

In this study, we were unable to examine all chronic conditions. Mental health conditions were not captured in our disease cohorts and are an important factor to consider when studying migrant health (Kirmayer et al., 2011). This is particularly important for immigrant populations at greater risk of morbidity, such as refugees, given their health disadvantage upon arrival and pre-migratory exposures to violence, disease and stress (A.-C. Hollander et al., 2012; A. C. Hollander, Bruce, Burström, & Ekblad, 2013; Reed & Barbosa, 2017; Hyman, 2010). Therefore, our findings may underestimate the immigrant populations' risk of developing a chronic condition, particularly among certain immigrant sub-groups. Moreover, since most chronic condition algorithms used in the ICES-derived disease cohorts favor specificity over sensitivity, there may have been an under-estimation of risk (refer to Appendix E for more information on each ICES-derived disease cohort).

Our immigrant cohort, derived from the IRCC database, contained 2.64% of the immigrant population classified as "Other", representing a small but diverse population of other immigrant categories under current Canadian immigration classification (Appendix C). Due to their small sample size, we were unable to ascertain the risk for "Other" immigrant categories and did not include them in our study population and analyses. However, we conducted separate analyses (not reported in this chapter) that revealed a similar level of risk to refugees when compared to long-term

Ontario residents. Future studies should investigate the characteristics of the "Other" immigrant category and their risk of developing a chronic condition and multimorbidity.

This study also focused only on first-generation immigrations in an adult population. Future studies should aim to capture second generation immigrants, and examine migrant health across the lifespan, particularly immigrant children from world regions of origin with a greater risk of developing a chronic condition. Future studies need to better examine acculturative stress processes, particularly changes in lifestyle and behavioural factors that impact health over time for immigrants in destination countries, and how sociocultural factors protect immigrants from morbidity (Rote & Markides, 2015; Beiser, 2005).

Finally, our study had limited social determinants of health including important lifestyle (e.g., smoking, diet, physical activity, alcohol consumption, occupation), behavioural factors (e.g., patterns of health seeking behaviours) and health care barriers that can impact how immigrants experience and health and well-being following settlement, as conceptualized in the CSDH framework. Our socio-economic indicator, using neighborhood-level income quintiles was only captured 3 years following an immigrants' arrival to Canada and limits our ability to contextualize the role of income and how it impacts both settlement and health outcomes over time.

2.5.3 Study Implications and Future Directions for Policy and Program Planning

This study can help inform current and future immigration policies around medical screening guidelines to better ensure a wide array of health issues, needs and conditions are captured in a timely and routine manner. This is particularly important for immigrant sub-populations, such as refugees, who are at greater risk of morbidity than other immigrant categories. Existing screening protocol have focused primary on communicable diseases; however, this becomes pertinent for chronic disease prevention and planning purposes, given the increasing number of refugee populations to North America and rising global rates of chronic diseases (Pottie et al., 2011).

This study also highlights the importance of not categorizing immigrants within the same group, given differences between refugee and immigrants, such as pre-migratory exposures to stress, violence, economic and political crises, and their socioeconomic circumstances (Beiser, 2005; Hyman, 2010). Our findings demonstrate the importance of considering the intersections of socio-demographic factors with migrant characteristics, such as immigrant category and world regions of origin, when examining the chronic health condition outcomes of immigrant populations.

Our findings can also aid policymakers and planners to develop specific screening guidelines and targeted educational programs within the healthcare system. Healthcare providers, public health officials and policy makers should focus on the development of effective health interventions that are culturally and linguistically tailored towards specific immigrant populations, for the prevention and management of chronic health conditions, including healthy lifestyle and behavioural factors.

Finally, this study highlights the critical importance of routine population-based data collection on immigration status and ethnicity/region of origin to help inform research, policy development, interventions and decision-making that impact long-term investments in preventive health services and chronic health management.

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CHAPTER 3 - RISK OF DEVELOPING MULTIMORBIDITY AMONG IMMIGRANTS AND LONG-TERM RESIDENTS AND ONTARIO FROM 1995-2010 IN ONTARIO, CANADA

ABSTRACT

Background: Multimorbidity is an important public health issue and has been associated with greater risk of adverse health outcomes, more frequent hospitalizations, greater healthcare needs, and premature death. The proportion of immigrants is also rapidly growing in Canada. Yet, limited research examining multimorbidity incidence and migration factors associated with it exists in Canada. This study examined patterns of and the risk of developing multimorbidity between immigrants and long-term residents of Ontario.

Methods: This study used a 1:1 matched retrospective observational open cohort design from 1995 to 2016, using routinely collected population-based administrative data at ICES. Multimorbidity was examined as: a) two or more (2+ multimorbidity) and b) three or more (3+ multimorbidity) co-occurring chronic conditions. Chronic disease frequencies of dyads and triads were examined for all immigrants and long-term residents of Ontario with multimorbidity. Stratified and multivariate Cox Proportional Hazard models were employed to examine the risk of developing multimorbidity between immigrants and long-term residents and by immigrant visa category and further by world regions of origin.

Results: A total of 2,312,244 immigrants and long-term Ontario residents were included in the study. Hypertension and diabetes, and in combination with Chronic Obstructive Pulmonary Disease were the leading multimorbidity dyad and triad groups for all immigrant categories and long-term residents of Ontario. After controlling for age, sex, and neighborhood income quintiles, refugees had the highest rate of developing 2+ multimorbidity, compared to long-term residents (HR:1.25 [95% CI: 1.21 –

1.29]). Immigrants from the Caribbean and South Asia had a greater risk of developing 2+ multimorbidity across all immigrant categories. Rates of multimorbidity (2+) varied for other world region of origins, by immigration visa category, compared to long-term residents. The risk of 3+ multimorbidity was higher among refugees from North Africa and the Middle East (HR = 1.22 [95% CI: 1.03-1.42]) as well as refugees (HR = 1.78 [95% CI: 1.59 – 1.98]), and family immigrants from South Asia (HR: 1.08 [95% CI: 1.02-1.14]), compared to long-term residents of Ontario.

Conclusions: Our study revealed emerging patterns of multimorbidity risk across different immigrant populations. An association between immigrants' visa category, their world region of origin and multimorbidity risk was found. These results highlight the importance of routine population-based data collection on immigration status and regions of origin to inform precision public health in research and policy development. Interventions and decision-making that impact long-term investments in preventive health services and management of multimorbidity need to be developed.

3.1 INTRODUCTION

3.1.1 Background

Multimorbidity is commonly defined as having two or more chronic conditions (Boyd and Fortin, 2010), and has been used as a general measure of overall health status (Diaz et al., 2015). It has also been used to assess health disparities by examining both individual and contextual factors contributing to the elevated risk of having two or more co-existing chronic conditions (Diaz et al., 2015; Starfield and Kinder, 2011; Prados-Torres et al., 2014).

Multimorbidity is an important public health issue and has been associated with greater risk of adverse health outcomes, more frequent hospitalizations, greater healthcare needs, and premature death (Rosella et al., 2014; Lofters et al., 2014; Pefoyo et al., 2015; Roberts et al., 2015; Agborsangaya et al., 2013; Boyd and Fortin, 2010).

Chronic diseases do not develop in isolation, due in large part to shared risk factors and the accumulation of disease with age (Muggah et al., 2012). Existing clinical guidelines are designed to manage specific chronic conditions and lack evidence-based, integrated treatments for patients with more than one existing chronic condition (Lenzi, Avaldi, Rucci, Pieri, & Fantini, 2016). A focus on multimorbidity is relevant to primary health care policy and practice. Research has shown that the annual mean primary health care use increases significantly with each additional chronic disease, where the burden of care and management of patients with multimorbidity falls largely on primary health care providers (Muggah, Graves, Bennett, & Manuel, 2012; Ryan et al., 2018).

3.1.2 Global Rates of Multimorbidity

The prevalence of multimorbidity is globally rising (Fortin, Hudon, Haggerty, Akker, & Almirall, 2010; Ryan et al., 2018; Smith, Soubhi, Fortin, Hudon, & O'Dowd, 2012a). A number of studies have examined multimorbidity prevalence, and estimates have varied due to differences in study design, types and numbers of chronic conditions considered in defining multimorbidity, data

sources and target population (Fortin et al., 2010; Roberts, Rao, Bennett, Loukine, & Jayaraman, 2015).

In the United States, a study examined multimorbidity using a general population survey to compare prevalence rates from 2001 to 2010. They reported that the prevalence of having two or more chronic conditions increased from 21.8% in 2001 to 26.0% in 2010 among those 18 years of age and older (Ward et al., 2013).

In the Netherlands, trends in the prevalence of multimorbidity showed an increased rate from 12.7% to 16.2% and 14.3% to 17.5% based on data from primary medical records and national health interview surveys respectively (van Oostrom et al., 2016). In England, a longitudinal study of the English population aged 50 years and older reported an increase in two or more chronic conditions from 31.7% in 2002/2003 to 43.1% in 2012/2013 (Dhalwani et al., 2016).

3.1.3 Multimorbidity in Canada

In Canada, there is limited population-based data on multimorbidity, yet it is becoming an increasingly common concern with an aging population, increased life expectancy and a steady rise in the prevalence of individual chronic conditions such as hypertension, diabetes and cardiovascular disease (Fortin, Hudon, Haggerty, Akker, & Almirall, 2010; Roberts, Rao, Bennett, Loukine, & Jayaraman, 2015; Ryan et al., 2018; Pefoyo et al., 2015).

Like global trends, estimates in Canada vary due to ongoing challenges in defining multimorbidity, differences in study design and age-cut-off points used in study populations (Agborsangaya et al., 2013; Boyd and Fortin, 2010).

In 2015, a study reported that 13% of Canadians aged 20 years and older had two or more chronic diseases using self-reported data from the 2011 Canadian Community Health Survey (Roberts et al., 2015). In another study, researchers used data from the Canadian Chronic Disease Surveillance System to estimate multimorbidity prevalence in Canada (Feely et a., 2017). Among

Canadians aged 40 years and over, the prevalence of having two or more and three or more chronic conditions was 20.5% and 6.8% in 2001/02, 26.5% and 10.2% in 2011/12, and 6.8% respectively (Feely et al., 2017).

A few studies in Canada have estimated the prevalence and associated risk factors of multimorbidity in select provinces and have reported increasing rates across all age groups (Pefoyo et al., 2015; Rosella et al., 2018). For example, a population-based study in Ontario reported 1-in-4 Ontarians had two or more co-occurring chronic conditions. They reported a 40% increase in the prevalence of multimorbidity from 2003 (17.4%) to 2009 (24.3%), compared to only a 4% increase in the prevalence of a single chronic disease over the same period (Pefoyo et al., 2015).

A recent retrospective cohort study estimated trends in the prevalence of multimorbidity at the time of death, using health administrative and population-based data, and reported an overall increase from 79.6% to 95.3% between 1994 to 2013. This increase was observed across all age groups with a disproportionately higher representation among individuals living in low-income neighborhoods and greater material deprivation (Rosella et al., 2018).

3.1.4 Multimorbidity and Immigrant Health

The proportion of immigrants is rapidly growing in Canada and is estimated to represent 28% of the total Canadian population (Cymbal & Bujnowski, 2010). Several studies have reported a 'healthy immigrant effect', where immigrants enjoy better health than non-immigrants, but over time in the host country, their health declines and becomes similar to, or worse than the health of non-immigrants (Fredericks & Guruge, 2015; Kennedy, Kidd, McDonald, & Biddle, 2015; Moullan & Jusot, 2014; Ro, Geronimus, Bound, Griffith, & Gee, 2015; Rote & Markides, 2015).

However, this health immigrant effect is not always apparent when examing health outcomes among different immigrant populations (Gee, Kobayashi, & Prus, 2004; Kobayashi & Prus, 2012; Oza-Frank & Venkat Narayan, 2010). The relationship between migration and health is

complex due to the heterogeneity of immigrants from different countries of origin and reasons for their migration (Bo et al., 2015; Norredam et al., 2014; Pottie et al., 2011; Cretore, 2013; Beiser, 2005; DesMeules et al., 2005).

Certain chronic conditions, such as diabetes and cardiovascular disease, are more prevalent among immigrants and refugees based on their ethnicity and world regions of origin (Taleshan, Petersen, Schioetz, Juul-Larsen, & Norredam, 2018; Tu et al., 2015; Norredam et al., 2014; Creatore, 2010). Barriers such as access to health care services, language and acculturation further contribute towards the elevated risk of disease among immigrants and refugees (Rouhani, 2011; Morris et al., 2009; Beiser, 2005). These factors combined place immigrants and refugees at greater risk of multimorbidity.

In Norway, a population-based study investigated length of stay and the prevalence of multimorbidity across different immigrant groups (Diaz, Kumar, et al., 2015). While all immigrants had lower rates of multimorbidity upon arrival, rates doubled after five years of settlement in Norway for all immigrants (refugees, labour immigrants, family reunification and education immigrants) compared to native-born Norwegians. Rates were also highest among refugees compared to other immigrant groups for both men and women (Diaz et al., 2015).

In Denmark, a historical prospective study investigated multimorbidity and mortality among refugees and family reunification immigrants, where refugees had higher risk of multimorbidity and family reunification immigrants had lower risk compared to Danish-born residents (Taleshan et al., 2018).

In Canada, research on the prevalence and determinants of multimorbidity among immigrants and refugee populations is limited. Roberts et al. (2015) examined data from the Canadian Community Health Survey and self-reported immigration status using a five-year cut-off point for immigrants living in Canada. Despite the healthy immigrant effect, the prevalence rate for

reporting two or more and three or more chronic diseases increased significantly after living in Canada for five or more years compared to those living in Canada less than five years (Roberts et al., 2015). Due to its cross-sectional study design, this study was unable to capture differences between immigrant sub-groups (e.g., refugees and other immigrants) nor establish causal relationships.

To our knowledge, there have been no longitudinal studies examining the development of multimorbidity incidence, migration factors associated with this risk, among immigrant populations and how their risk differs from the general population in Canada. Data addressing health differences among immigrants and refugees has become available in more recent years to select Canadian provinces for research purposes.

This study addresses some of these knowledge gaps and utilizes population-based immigrant and health data housed at ICES with the ability to conduct analyses, by various migration characteristics, that could impact the risk of multimorbidity among immigrants over time.

3.1.5 Objectives

The objective of this study is to estimate and compare the risk of multimorbidity between disease-free immigrant groups and long-term residents of Ontario, and to describe patterns of multimorbidity in this heterogeneous population.

3.2 METHODOLOGY

3.2.1 Ethics

Ethics approval was obtained from the University of Ottawa Health Science and Science Research and Ethics Board. No patients were recruited for the study. This study used de-identified population-based health administrative data at ICES. ICES is an independent, non-profit research institute funded by an annual grant from the Ontario Ministry of Health and Ministry of Long-Term Care (MOH and MLTC). As a prescribed entity under Ontario's privacy legislation, ICES is authorized to collect and use health care data for the purposes of health system analysis, evaluation,

and decision support. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario.

3.2.2 Study Design, Setting and Data Sources

This study is a matched retrospective observational cohort design covering 1995 to 2016 using routinely collected administrative data. The study consists of an open cohort of individuals entering the study, at different points in time, using routinely collected administrative data at ICES.

ICES holds data on patient socio-demographic and economic information, healthcare utilization, immigration data and medical profiles for individuals eligible for universal health coverage in Ontario. The project consisted of analyses from several linked databases using unique encoded identifiers and analyzed at ICES.

The Registered Persons Database (RPDB) is an electronic registry used to identify long-term residents eligible for health coverage in Ontario. The Immigrant and Refugees Citizenship Canada Permanent Residents Database (IRCC) was used to identify immigrants. It is a registry of all landed immigrants to Canada since 1985 and contains individual-level information of all immigrants, who identified Ontario as a declared destination, at the time of their landing (ICES, 2019a).

We used the Ontario Health Insurance Plan Billing Data (OHIP) to identify immigrants and long-term residents who have had an interaction with the healthcare system. OHIP is the provincial health program database providing publicly funded universal health services through the

Ontario Ministry of Health and Ministry of Long-term care to approximately 95% of Ontario residents [14].

We used CENSUS data and Postal Code Conversion Files (PCCF+) to collect sociodemographic information and geographic area of residence based on urban and rural geographic areas. The Census survey is conducted by Statistics Canada on the Canadian population every five years. It is presented as area profiles, and contains age, sex, marital status/common law status, mother tongue and other socio-economic data that are collected (Statistics Canada, 2019).

The PCCF+ is a file which provides the correspondence between each postal code in Ontario and Statistics Canada standard geographic areas and is updated every five years (ICES, 2013). In this study, we used Census and PCCF+ data for 1996, 2001, 2006 and 2011 depending on the index year for which immigrants and long-term residents entered the study.

The study also included nine ICES-derived disease cohorts to capture diagnoses of chronic conditions. These chronic conditions have been defined from previously validated population-derived ICES cohorts using linked data algorithms derived from health administrative data held at ICES (ICES, 2019b). Refer to Appendix E more information on each ICES-derived disease cohort creation.

These chronic conditions include: the Ontario Asthma Dataset (Gershon, Wang, Guan, Frcpc, et al., 2009; Gershon, Wang, Guan, Vasilevska-Ristovska, et al., 2009; To et al., 2006), Ontario Congestive Heart Failure Dataset (Schultz, Rothwell, Chen, & Tu, 2013), Ontario Chronic

[14] OHIP does not cover health services for First Nation populations on reserves and members of the Armed Forces who receive health coverage through other federally funded programs. ICES contains most claims paid for by OHIP covering all health care providers who can claim under OHIP. This includes physicians, groups, laboratories, and out-of-province providers (ICES, 2017).

Obstructive Pulmonary Disease dataset (Gershon, Wang, Guan, Vasilevska-Ristovska, et al., 2009), Ontario Hypertension Dataset (Tu, Campbell, Chen, Cauch-Dudek, & McAlister, 2007; Tu, Chen, & Lipscombe, 2008), Ontario Crohn's and Colitis Cohort Dataset (Benchimol et al., 2009; Benchimol et al., 2014), the Ontario Diabetes Dataset (Guttmann et al., 2010; Lipscombe et al., 2018), the Ontario Myocardial Infarction Dataset (Austin, Daly, & Tu, 2002), the Ontario Rheumatoid Arthritis Dataset (Widdifield et al., 2013, 2014), and Cancer records from the Ontario Cancer Registry (ICES, 2018).

3.2.3 Participants

We identified immigrants who landed in Ontario between 1992 and 2010 using the IRCC database, limited that cohort to individuals 18 to 70 years of age at landing, and have resided in Ontario for three years following their landing. Immigrants must have been eligible for OHIP coverage, and were disease free on December 31, three years following their landing year, in all the ICES-derived disease cohorts included in our study. The three years follow up period is required to allow enough interactions with the healthcare system to establish the presence of chronic conditions using the algorithms on which the ICES-derived disease cohort rely. We limited our immigrant cohort to those with an immigration visa entry classified as a refugee, family, or economic category (this includes over 97% of all immigrants) (Appendix A).

Once eligible immigrants were identified, a long-term resident of Ontario was matched 1:1 to each immigrant by age, sex, and rurality (Rurality Index of Ontario (RIO)>45 (yes/no) (using RPDB and PCCF+ data files) at the time of eligibility (three years after landing).

Long-term Ontario residents must have resided in Ontario for at least ten years prior to the year of matching, been disease-free from all the ICES-derived disease cohorts on December 31 in the year of matching, and not included in the IRCC database at any point in time. Most long-term Ontario residents are born in Canada but may include immigrants who have settled in Ontario

before 1985. We cannot ascertain OHIP eligibility from birth for individuals born prior to 1991, since we only have OHIP records from 1991. Individuals in the long-term Ontario resident cohort must have had an Ontario postal code before January 1, 1994, been eligible for OHIP coverage from 1991 to 1994 and not be in the IRCC database at any time simultaneously, to avoid potential misclassification of immigrants in the long-term resident group (refer to Appendices A and B for an illustration on the cohort creation and matching).

Only matched long-term residents were retained; all other long-term Ontario residents were removed from the dataset. The matched immigrant and long-term resident cohort was then linked to the other datasets at ICES.

3.2.4 Variables

Outcome Variables

Our primary outcome variable examined multimorbidity as: a) Two or more (yes/no) and b) Three or more (yes/no) co-occurring chronic conditions using individuals with no chronic condition as the reference group. We examined multimorbidity using the nine chronic health conditions that were available from the ICES derived disease cohorts. These chronic conditions were the only validated ICES-derived disease cohorts that were available at the time of the study (ICES, 2019).

Independent Variables

Our study contained both socio-demographic and immigration variables that were available from linking multiple datasets at ICES (Appendix F). We were interested in whether an individual was an immigrant (yes/no) belonging to one of the three immigrant categories (refugee, family, or economic immigrant (refer to Appendix C for a list of how immigrant categories were grouped using data from the Immigration, Refugee and Citizenship Canada Landed Immigrant Dataset) as our primary covariate.

Our sociodemographic variables included age (categorized 18-29, 30-44, 45+), sex (Male/Female), which were directly derived from health administrative records, and neighborhood level income quintiles (Q1 to Q5) since individual-level data was not available for income. The Census files assign relative income quintiles based on the smallest geographical unit for which the census data is available and are adjusted for household and community size. Residential postal code for an individual was linked to dissemination- level income data collected for the 1996, 2001, 2006 and 2011 Canadian census using the PCCF+ files which corresponded to their respective Census files.

We derived our immigration variables from the IRCC database which contained individual-level data on an immigrants' visa category (Refugee, Family, Economic), country of origin, their year of landing in Ontario, level of education (Secondary or less, Non-University Qualifications/Some University, University degree or higher) and official language proficiency (English, French or both) at the time of their landing.

We derived a world region of origin variable using the country-of-origin data, since the IRCC database included immigrants from over 200 different countries. We grouped countries into world regions of origin (Appendix D) based on the World Bank schema and further by ethnic grouping to obtain the following categories: the Caribbean, East Asia and the Pacific, South Asia, Eastern Europe and Central Asia, North Africa and the Middle East, Latin America, Western Europe and the US, and sub-Saharan Africa. This is a method that has been applied in previous studies using ICES data (Lazo-Langner et al., 2018; Vahabi et al., 2016; Durbin et al., 2015; Urquia et al., 2015; Cretore, 2010).

We grouped individuals by their landing year to create five distinct landing cohorts of immigration to include as a covariate in our analyses – those landing between 1992-1995, 1996-1999,

2000-2003, 2004-2007, and 2008-2010. These categorizations were arbitrary, aimed at producing five distinct landing cohorts of the same interval, except for the 2008-2010 group.

3.2.5 Statistical Methods

Descriptive Analysis

For all our analyses, we examined the effect of immigration on the risk of multimorbidity, stratifying by immigrant visa categories to account for the heterogeneity among immigrant populations, as conceptualized by the CSDH framework on the social determinants of health.

First, we examined the distribution (n%) of having at least one chronic condition, multimorbidity (2 or more and 3 or more co-occurring chronic conditions), and multimorbidity counts, among immigrant categories and long-term residents, during the study observation period of 1995 to 2016.

Assessing chronic conditions groups

We examined the proportion (n%) of which chronic conditions were most prevalent as dyads (2+ chronic conditions) and triads (3+ chronic conditions), for all immigrant categories and long-term residents of Ontario with multimorbidity, to compare trends and differences in emerging conditions.

Overall estimate of risk

We calculated multimorbidity risk between immigrant categories (refugees, family, and economic class immigrants) and long-term Ontario residents during the follow up period of 1995 to 2016. We defined risk as the number of multimorbidity events/1000 person-years.

A multimorbidity event for two or more co-occurring chronic conditions was defined as the diagnosis of a second chronic condition for individuals with one condition. For three or more co-occurring chronic conditions, we defined multimorbidity event as the diagnosis of a third chronic

condition for individuals with two co-occurring conditions. Disease-free immigrants and long-term residents were followed forward in time from study start date (baseline) to last follow-up (event, death, loss of OHIP eligibility, or end of the study observation period).

We calculated unadjusted incidence rates, per 1000 person-years follow-up, for having a) at least 1 condition (Yes/No), b) two or more (Yes/No) and c) three or more (Yes/No) chronic conditions co-occurring, for each immigrant category and long-term resident, using individuals with no chronic condition as the reference group. We calculated the incidence of having a single condition as a comparison to those with multimorbidity.

We then estimated the relative risk for each immigrant category compared to long-term Ontario residents. Stratified analyses were also performed to estimate the relative risk for immigrant categories, by sociodemographic (age, sex, neighborhood income quintiles) and migration profile (world regions of origin, landing period, education, and language proficiency upon landing), compared to long-term residents.

Regression modelling

We used Cox Proportional Hazard Models to examine the risk of multimorbidity over time. Disease-free immigrants and long-term residents were followed from baseline to multimorbidity event or last follow up. Individuals for whom death, loss of OHIP eligibility or the end of the observation period occurred before the event were censored at that date.

To account for the heterogeneity among immigrant populations, we examined the risk of multimorbidity by an immigrants' visa category and further by their world regions of origin. We hypothesized there are differences across different strata of immigrant sub-populations. This informed our analytic approach to stratify our regression analyses by immigrant visa categories. We further hypothesized differences in the effect size of being an immigrant, on multimorbidity

outcomes, by an immigrants' world region of origin when comparing their risk to long-term residents.

We built three stratified multivariate models, by immigrant visa category (refugee, family, economic class immigrants) to estimate the hazard ratio (HR) and 95% Confidence Intervals (CI) of multimorbidity risk for having two or more chronic conditions, compared to long-term residents. The same method was applied for examining the multimorbidity risk of having three or more chronic conditions co-occurring. The multivariate models were adjusted by immigrant status, age, sex, and neighborhood-level income quintiles as shown in the formula presented below:

Multimorbidity Outcomes= Immigrant (yes/no) + Age Category + Sex + Neighborhood level income

We also examined the risk of immigrants developing multimorbidity by their world regions of origin. We used the stratified models described above and included an interaction term for immigrant status (yes/no) and world regions of origin to estimate the risk of multimorbidity for immigrants, by their world region of origin, when compared to long-term residents.

For each stratified immigrant visa category model, we estimated effect sizes on multimorbidity outcomes for the world region of origin interaction term using the same approach as discussed in Chapter 2. All analyses were conducted with SAS software, version 9.4 (SAS Institute Inc., Cary, NC).

A matched analysis was not performed on the data. In all multivariate models, we adjusted for age and sex, which were variables used to match immigrants and long-term residents in the study design. A matched analysis was not needed when analyzing matched cohort data, but it was recommended to adjust for the matching variables in the statistical analysis. This is a method that has previously been used on matched cohort data (Sjölander & Greenland, 2013). Ignoring the

matching variables in a cohort study can introduce bias when additional confounders are present, even after adjusting for the additional confounders. This bias is avoided by adjusting for the matching variables (Sjölander & Greenland, 2013). Appendix G provides more information on the rationale of the analytic approaches used for the matching and analyses throughout this dissertation.

All analyses were conducted with SAS software, version 9.4 (SAS Institute Inc., Cary, NC).

3.3 RESULTS

A total of 2,037,657 immigrants landed in Ontario between 1992 to 2010. Of these, 1,156,122 were disease-free and continued to reside in Ontario three years after landing. Each immigrant was matched to a long-term resident, resulting in a total of 2,312,244 individuals, entering the cohort at different points in time, that were followed forward until December 31, 2016.

3.3.1 Descriptive data

Table 3.1 shows the distribution of multimorbidity for immigrant categories and long-term residents at last follow up. The proportion of multimorbidity counts varied across immigrant categories and long-term residents of Ontario. The proportion of having 2+ co-occurring chronic conditions was highest among refugees (8.4%) compared to other immigrant categories and long-term residents.

Table 3.2 shows the top ten disease dyads among each immigrant category and long-term residents. Hypertension and diabetes accounted for the most prevalent disease dyad in the study population. The prevalence of disease dyads varied across long-term residents and immigrant categories. Among long-term residents of Ontario, disease dyads such as COPD and hypertension (23.9%), hypertension and cancer (13.5%), CHF and hypertension (9.4%), hypertension and Myocardial Infarction (7.4%) and asthma and COPD (10.5%) were highest compared to other immigrant categories. Disease dyads such as diabetes and asthma were higher across all immigrant categories compared to long-term residents, and highest among refugees (11.6%).

Hypertension, COPD, and diabetes was the most common disease triad for all immigrants and long-term Ontario residents, and was highest among long-term residents (24.8%) followed by refugees (23.3%) (Table 3.3). The prevalence of other disease triads varied across immigrant categories and long-term residents.

3.3.2 Unadjusted findings

Table 3.4 displays the unadjusted relative risk for having 1+, 2+ and 3+ co-occurring chronic conditions for each immigrant category compared to long-term residents. Refugees had the highest relative risk (1+: 1.25 [95% CI: 1.24 – 1.26]; 2+: 1.36 [95% CI: 1.32 – 1.40]; 3+: 1.19 [95% CI: 1.13 – 1.26]) compared to long-term residents. The relative risk for refugees was highest compared to other immigrant categories. Economic immigrants had the lowest overall relative risk compared to long-term residents (1+: 0.90 [95% CI: 0.89 – 0.91]; 2+: 0.87 [95 % CI: 0.86 – 0.88]; 3+: 0.67 [95% CI: 0.64 – 0.69]).

The unadjusted relative risk, stratified by socio-demographic and migrant characteristics, remained highest among refugees compared to long-term residents, as well as other immigrant categories. The unadjusted relative risks were higher with lower neighborhood income quintiles, lower education level at landing and more recent landing cohorts for all immigrant categories. The relative risk increased with older age, across all immigrant categories, and varied by immigrant categories. The relative risk of having 2+ and 3+ co-occurring conditions were the highest among refugees, by age, when compared to long-term residents, and were most pronounced in the 18 to 29 age group (2+ 1.45, 95% CI: 1.33 – 1.57; 3+ 1.41, 95 % CI: 1.21 – 1.84).

The relative risk among immigrant categories, differed by world region of origin, compared to long-term residents. Immigrants from the Caribbean and South Asia had the highest relative compared to long-term resident irrespective of their immigration category. The relative risk for certain world regions differed by their immigration category (Table 3.4).

3.3.3 Adjusted multivariate models

Table 3.5 and 3.7 present the adjusted Hazard Ratios (HR) and 95 % Confidence Intervals (CI) from the stratified multivariate cox proportional hazard models, by immigrant category, for having two or more and three or more chronic conditions. After adjusting for immigrant status, age, sex, and neighborhood income quintiles, refugees had the highest rate of multimorbidity (2+ chronic conditions), compared to long-term residents (HR:1.25 [95% CI: 1.21 – 1.29]). Family and Economic class immigrants had lower risk of having 2+ multimorbidity than long-term residents. The risk of multimorbidity reduced for all immigrant categories, with 3+ co-occurring conditions, in the adjusted multivariate models (Table 3.7) and remained lower for both family and economic class immigrants compared to long-term residents.

In all the stratified multivariate models (2+ and 3+ multimorbidity), the risk increased with older age and was lower among women compared to men. The risk also increased with lower neighborhood income quintiles compared to individuals in the higher income quintile groups.

Table 3.6 and 3.8 present the adjusted HRs and 95% CI for each immigrants' world region of origin obtained from the inclusion of the interaction term in the stratified multivariate cox proportional hazard models, for each immigrant category, for having two or more and three or more chronic conditions, respectively. The HRs by world regions of origin were adjusted by age, sex, and neighborhood-level income. The complete multivariate model outputs where the interaction terms were included in the analyses are presented in Appendix J. Immigrants from the Caribbean and South Asia had a greater risk of having 2+ co-occurring conditions, across all immigrant categories, after adjusting for age, sex, and neighborhood income quintiles (Figures 3.1-3.3).

Rates of multimorbidity (2+) among immigrants varied by world region of origin, when compared to long-term residents, depending on their immigration category (Figures 3.1-3.3). Among refugees, immigrants from North Africa and the Middle East (HR: 1.16 [95% CI: 1.08 – 1.24]), sub-

Saharan Africa (HR: 1.20 [95% CI: 1.12 – 1.29], Western Europe and the US (HR: 1.71 [95% CI: 1.11 – 2.32]) had a higher risk compared to long-term Ontario residents (Figure 3.1). Among family class immigrants, individuals from Latin America & Mexico had a higher risk of having 2+ chronic conditions (HR: 1.11 [95% CI: 1.05 – 1.17] compared to long-term residents (Figure 3.2).

When we examined the risk of having three or more co-occurring conditions, we found no difference or a lower risk, by world region of origin, among economic class immigrants, compared to long-term residents. Among family class immigrants, we found a slightly elevated risk of multimorbidity (3+) among immigrants from South Asia (HR: 1.08 [95% CI: 1.02-1.14]) compared to long-term residents. Among refugees, the risk of multimorbidity was higher among individuals from North Africa and the Middle East (HR = 1.22 [95% CI: 1.03-1.42]) and South Asia (HR = 1.78 [95% CI: 1.59 – 1.98]) compared to long-term residents of Ontario.

3.4 TABLES AND FIGURES

Table 3.1 Distribution of multimorbidity (n, %) for immigrant categories and long-term residents of Ontario from 1995-2016

	Immigrant Categories							
	LONG-TERM RESIDENTS		REFUGEES		FAMILY CLASS IMMIGRANTS		ECONOMIC CLASS IMMIGRANTS	
	n	%	n	%	n	%	n	%
POPULATION	**1,156,122**	**—**	**151,826**	**—**	**417,562**	**—**	**586,734**	**—**
Multimorbidity								
One or more	278,831	(24.1)	42,494	(28.0)	108,088	(25.9)	127,406	(21.6)
Two or more	78,927	(6.8)	12,699	(8.4)	33,654	(8.1)	31,695	(5.4)
Three or more	20,314	(1.8)	2,695	(1.8)	8,040	(1.9)	5,540	(0.9)
Number of chronic conditions								
One	199,904	(71.7)	29,795	(70.1)	74,434	(68.9)	95,711	(75.1)
Two	58,613	(21.0)	10,004	(23.5)	25,614	(23.7)	26,155	(20.5)
Three	15,441	(5.5)	2,187	(5.2)	6,194	(5.7)	4,612	(3.6)
Four+	4,873	(1.8)	508	(1.2)	1,846	(1.7)	928	(0.7)

Note: 4+ multimorbidity goes up to 7 chronic conditions co-occurring in this study population

Table 3.2 Top 10 Disease Dyads (n, %)

	Long-term Residents		Refugees		Family		Economic	
	n	%	n	%	n	%	n	%
Hypertension and Diabetes	31,362	(39.7)	7,212	(56.8)	19,285	(57.3)	18,609	(58.7)
Asthma and Hypertension	10,772	(13.6)	2,164	(17.0)	5,955	(17.7)	4,551	(14.4)
COPD and Hypertension	18,845	(23.9)	1,760	(13.9)	5,093	(15.1)	3,584	(11.3)
Hypertension and Cancer	10,665	(13.5)	798	(6.3)	3,422	(10.2)	2,741	(8.6)
Asthma and Diabetes	4,772	(6.0)	1,474	(11.6)	3,298	(9.8)	2,564	(8.1)
COPD and Diabetes	8,296	(10.5)	1,098	(8.6)	2,568	(7.6)	2,044	(6.4)
CHF and Hypertension	7,455	(9.4)	640	(5.0)	2,843	(8.4)	1,367	(4.3)
Hypertension and MI	5,820	(7.4)	701	(5.5)	1,594	(4.7)	1,723	(5.4)
Asthma and COPD	8,298	(10.5)	900	(7.1)	2,395	(7.1)	1,679	(5.3)
Cancer and Diabetes	4,351	(5.5)	502	(4.0)	1,747	(5.2)	1,486	(4.7)

Note: Denominator for n% calculations are based on total *n* size of individuals with 2+ multimorbidity

Table 3.3 Top 5 Disease Triads (n, %)

	Long-term Residents		Refugees		Family		Economic	
	n	%	n	%	n	%	n	%
COPD Hypertension Diabetes	5,032	(24.8)	627	(23.3)	1,810	(22.5)	1,153	(20.8)
Hypertension Cancer Diabetes	2,710	(13.3)	283	(10.5)	1,165	(14.5)	852	(15.4)
CHF Hypertension Diabetes	2,694	(13.3)	312	(11.6)	1,268	(15.8)	600	(10.8)
Hypertension Diabetes MI	1,927	(9.5)	332	(12.3)	706	(8.8)	707	(12.8)
CHF COPD Hypertension	2,505	(12.3)	126	(4.7)	708	(8.8)	197	(3.6)

Note: Denominator for n, % calculations are based on total *n* size of individuals with 3+ multimorbidity

Table 3.4 Unadjusted Relative Risk (RR) of Multimorbidity (1+, 2+ and 3+ diseases co-occurring) and 95% Confidence Intervals (C.I) for Immigrant Categories and long-term residents per 1000 person-years follow up, 1995—2016

	IMMIGRANT CATEGORIES																	
	REFUGEES						FAMILY						ECONOMIC					
	Multimorbidity Incidence						Multimorbidity Incidence						Multimorbidity Incidence					
	1+		2+		3+		1+		2+		3+		1+		2+		3+	
	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.
OVERALL	1.25	(1.24—1.26)	1.36	(1.32—1.40)	1.19	(1.13—1.26)	1.00	(0.99—1.01)	1.00	(0.99—1.02)	0.82	(0.79—0.84)	0.90	(0.89—0.91)	0.87	(0.86—0.88)	0.67	(0.64—0.69)
SEX																		
Males	1.24	(1.22—1.26)	1.34	(1.29—1.39)	1.14	(1.07—1.23)	1.04	(1.03—1.05)	1.00	(0.98—1.02)	0.82	(0.79—0.86)	0.90	(0.89—0.91)	0.85	(0.84—0.87)	0.67	(0.64—0.70)
Females	1.28	(1.25—1.31)	1.41	(1.33—1.47)	1.27	(1.16—1.40)	1.01	(0.99—1.02)	1.00	(0.98—1.03)	0.81	(0.78—0.85)	0.91	(0.90—0.92)	0.89	(0.87—0.91)	0.67	(0.63—0.70)
AGE CATEGORIES (BASELINE)																		
18-29	1.23	(1.19—1.27)	1.45	(1.33—1.57)	1.51	(1.21—1.84)	1.19	(1.17—1.21)	1.26	(1.20—1.31)	1.01	(0.89—1.15)	0.88	(0.86—0.90)	0.89	(0.83—0.95)	0.70	(0.58—0.84)
30-44	1.27	(1.23—1.29)	1.36	(1.31—1.41)	1.16	(1.07—1.25)	1.10	(1.08—1.12)	1.18	(1.14—1.21)	0.98	(0.92—1.05)	0.92	(0.91—0.93)	0.90	(0.88—0.91)	0.69	(0.66—0.72)
45+	1.30	(1.26—1.34)	1.36	(1.30—1.42)	1.17	(1.07—1.27)	0.87	(0.86—0.88)	0.90	(0.88—0.91)	0.77	(0.74—0.80)	0.86	(0.85—0.87)	0.82	(0.80—0.84)	0.64	(0.61—0.67)
INCOME QUINTILES																		
Q1 (lowest income)	1.31	(1.28—1.34)	1.43	(1.38—1.48)	1.21	(1.12—1.30)	1.15	(1.13—1.17)	1.20	(1.17—1.23)	1.05	(1.00—1.11)	1.01	(1.00—1.03)	1.04	(1.01—1.06)	0.83	(0.78—0.88)
Q2	1.26	(1.22—1.30)	1.34	(1.26—1.42)	1.13	(1.00—1.28)	1.03	(1.02—1.04)	1.04	(1.01—1.07)	0.84	(0.79—0.89)	0.94	(0.92—0.96)	0.91	(0.88—0.94)	0.74	(0.69—0.80)
Q3	1.23	(1.19—1.27)	1.36	(1.25—1.47)	1.36	(1.13—1.60)	0.98	(0.96—1.00)	0.96	(0.93—1.00)	0.74	(0.69—0.79)	0.89	(0.88—0.90)	0.85	(0.82—0.88)	0.63	(0.58—0.68)
Q4	1.15	(1.09—1.21)	1.19	(1.06—1.32)	1.06	(0.80—1.33)	0.90	(0.88—0.92)	0.84	(0.81—0.87)	0.68	(0.62—0.73)	0.84	(0.83—0.85)	0.77	(0.74—0.80)	0.55	(0.51—0.61)
Q5	1.09	(1.02—1.16)	1.16	(1.01—1.33)	1.04	(0.70—1.39)	0.75	(0.73—0.77)	0.67	(0.63—0.70)	0.49	(0.44—0.54)	0.72	(0.70—0.74)	0.61	(0.59—0.64)	0.44	(0.40—0.48)
EDUCATIONAL LEVEL AT LANDING																		
Secondary or Less	1.34	(1.31—1.37)	1.52	(1.46—1.57)	1.39	(1.29—1.50)	1.05	(1.04—1.06)	1.04	(1.02—1.06)	0.85	(0.82—0.87)	0.98	(0.96—1.00)	0.98	(0.95—1.01)	0.76	(0.71—0.81)
Non-University Qualifications/ Some University	1.19	(1.16—1.22)	1.24	(1.19—1.31)	1.06	(0.95—1.17)	1.01	(0.99—1.03)	0.96	(0.93—0.99)	0.78	(0.72—0.83)	0.93	(0.92—0.94)	0.88	(0.86—0.91)	0.70	(0.65—0.74)
University Degree or Higher	1.09	(1.05—1.13)	1.10	(1.02—1.18)	0.83	(0.71—0.96)	0.95	(0.93—0.97)	0.90	(0.87—0.94)	0.70	(0.64—0.77)	0.87	(0.86—0.88)	0.81	(0.80—0.83)	0.60	(0.56—0.63)
WORLD REGION OF ORIGIN																		
Caribbean	1.26	(1.08—1.44)	1.29	(0.98—1.61)	1.34	(0.75—1.94)	1.29	(1.25—1.33)	1.31	(1.25—1.38)	1.07	(0.96—1.19)	1.33	(1.28—1.38)	1.44	(1.33—1.55)	1.16	(0.99—1.36)
East Asia & the Pacific	1.02	(0.97—1.07)	0.94	(0.85—1.05)	0.64	(0.51—0.81)	0.83	(0.82—0.84)	0.77	(0.75—0.80)	0.58	(0.55—0.62)	0.78	(0.77—0.79)	0.67	(0.66—0.69)	0.45	(0.42—0.47)
Eastern Europe & Central Asia	0.98	(0.95—1.01)	0.94	(0.88—0.99)	0.80	(0.71—0.90)	0.85	(0.83—0.87)	0.80	(0.76—0.84)	0.72	(0.66—0.80)	0.82	(0.81—0.83)	0.72	(0.69—0.75)	0.64	(0.59—0.70)
Latin America & Mexico	0.97	(0.92—1.02)	0.88	(0.79—0.97)	0.66	(0.53—0.81)	1.07	(1.04—1.10)	1.18	(1.12—1.25)	0.96	(0.86—1.07)	0.83	(0.80—0.86)	0.87	(0.80—0.95)	0.77	(0.65—0.92)
North Africa & the Middle East	1.13	(1.08—1.18)	1.24	(1.15—1.33)	1.35	(1.16—1.57)	0.92	(0.90—0.94)	0.92	(0.85—0.98)	0.79	(0.69—0.90)	0.81	(0.79—0.83)	0.81	(0.77—0.85)	0.76	(0.68—0.85)
South Asia	1.78	(1.74—1.82)	2.21	(2.10—2.32)	1.99	(1.79—2.20)	1.33	(1.31—1.35)	1.38	(1.34—1.43)	1.17	(1.11—1.24)	1.27	(1.25—1.29)	1.46	(1.41—1.50)	1.14	(1.06—1.22)

Table 3.4 Unadjusted Relative Risk (RR) of Multimorbidity (1+, 2+ and 3+ diseases co-occurring) and 95% Confidence Intervals (C.I) for Immigrant Categories and long-term residents per 1000 person-years follow up, 1995—2016

	IMMIGRANT CATEGORIES																	
	REFUGEES						FAMILY						ECONOMIC					
	Multimorbidity Incidence						Multimorbidity Incidence						Multimorbidity Incidence					
	1+		2+		3+		1+		2+		3+		1+		2+		3+	
	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.
Sub-Saharan Africa	1.29	(1.24—1.34)	1.33	(1.25—1.43)	1.14	(0.96—1.33)	1.18	(1.13—1.23)	1.05	(0.97—1.14)	0.83	(0.69—0.98)	1.01	(0.97—1.05)	0.90	(0.82—0.98)	0.71	(0.59—0.85)
Western Europe & US	1.15	(0.87—1.43)	1.79	(1.16—2.43)	1.74	(0.76—2.73)	0.72	(0.69—0.75)	0.71	(0.67—0.76)	0.70	(0.62—0.79)	0.61	(0.59—0.63)	0.52	(0.49—0.56)	0.44	(0.38—0.51)
LANGUAGE PROFICIENCY ON LANDING																		
None	1.19	(1.16—1.22)	1.32	(1.26—1.38)	1.14	(1.04—1.25)	0.99	(0.98—1.00)	0.95	(0.93—0.97)	0.76	(0.73—0.79)	0.80	(0.79—0.81)	0.72	(0.70—0.74)	0.54	(0.50—0.59)
English, French or Both	1.29	(1.26—1.31)	1.39	(1.34—1.44)	1.21	(1.12—1.31)	1.05	(1.04—1.06)	1.07	(1.05—1.10)	0.91	(0.86—0.95)	0.94	(0.93—0.95)	0.91	(0.90—0.93)	0.70	(0.68—0.73)
LANDING COHORT (YEAR OF ARRIVAL)																		
1992-1995	1.16	(1.13—1.19)	1.25	(1.21—1.30)	1.10	(1.03—1.18)	0.94	(0.93—0.95)	0.95	(0.93—0.97)	0.79	(0.77—0.82)	0.86	(0.85—0.87)	0.85	(0.83—0.87)	0.69	(0.66—0.72)
1996-1999	1.24	(1.20—1.28)	1.38	(1.31—1.46)	1.30	(1.14—1.47)	1.02	(1.00—1.04)	1.02	(0.98—1.05)	0.84	(0.79—0.90)	0.82	(0.81—0.83)	0.83	(0.80—0.85)	0.63	(0.59—0.67)
2000-2003	1.38	(1.33—1.43)	1.70	(1.59—1.82)	1.62	(1.31—1.94)	1.09	(1.07—1.11)	1.12	(1.08—1.17)	0.89	(0.82—0.98)	0.91	(0.90—0.93)	0.89	(0.86—0.92)	0.65	(0.59—0.71)
2004-2007	1.38	(1.33—1.43)	1.59	(1.45—1.75)	1.10	(0.72—1.49)	1.17	(1.14—1.20)	1.29	(1.21—1.38)	1.05	(0.86—1.25)	1.08	(1.06—1.10)	1.12	(1.06—1.19)	0.87	(0.74—1.02)
2008-2010	1.65	(1.50—1.80)	2.13	(1.47—2.80)	3.46	(1.14—5.76)	1.32	(1.27—1.39)	1.26	(1.07—1.46)	0.93	(0.38—1.49)	1.36	(1.31—1.41)	1.45	(1.25—1.66)	0.89	(0.56—1.21)

Table 3.5 Hazard Ratios (HR) and 95% Confidence Intervals (C.I): Multivariate Cox Proportional Hazard Model of Multimorbidity (2+), by Immigrant Categories compared to Long-term Residents of Ontario.

	Immigrant Categories					
	Refugee N=151, 698		**Family N=417, 422**		**Economic N=586, 560**	
	Hazard Ratio	**95% C.I.**	**Hazard Ratio**	**95% C.I.**	**Hazard Ratio**	**95% C.I.**
Immigrant (Yes)	1.25	(1.21—1.29)	0.94	(0.92—0.96)	0.84	(0.83—0.85)
Age Category						
18-29 (reference)	—	—	—	—	—	—
30-44	2.78	(2.67—2.90)	2.53	(2.46—2.59)	2.68	(2.59—2.78)
45+	7.84	(7.49—8.20)	10.9	(10.6—11.2)	7.00	(6.76—7.25)
Sex						
Female	0.87	(0.85—0.89)	0.78	(0.76—0.80)	0.84	(0.83—0.85)
Male (reference)	—	—	—	—	—	—
Income Quintile						
Q1 (lowest income)	1.41	(1.34—1.48)	1.57	(1.53—1.61)	1.56	(1.52—1.60)
Q2	1.26	(1.19—1.33)	1.38	(1.34—1.41)	1.42	(1.38—1.45)
Q3	1.19	(1.12—1.26)	1.28	(1.25—1.31)	1.31	(1.27—1.34)
Q4	1.10	(1.04—1.17)	1.15	(1.11—1.18)	1.19	(1.16—1.23)
Q5 (reference)	—	—	—	—	—	—

* The N size of long-term residents is equal to the N displayed for each immigrant category.

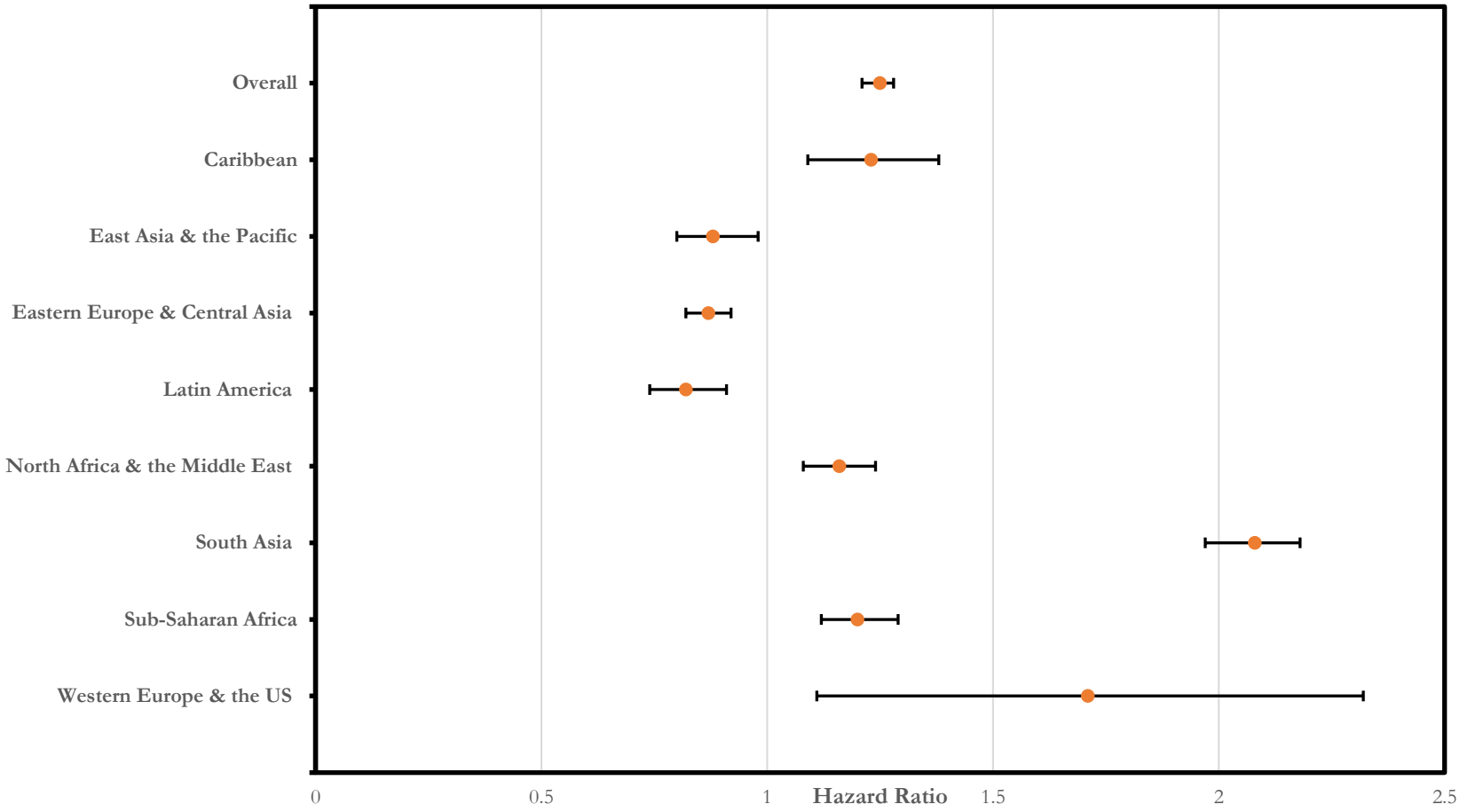
Table 3.6 Adjusted Hazard Ratios (HR) and 95% Confidence Intervals (C.I) of developing Multimorbidity (2+) by World Regions of Origin, for Immigrant Categories compared to long-term residents, 1995-2016.

Immigrant Categories World Region of Origin	Hazard Ratio	95% C.I.
REFUGEES N= 151,053		
Caribbean	1.23	1.09—1.38
East Asia & the Pacific	0.88	0.80—0.98
Eastern Europe & Central Asia	0.87	0.82—0.92
Latin America	0.82	0.74—0.91
North Africa & the Middle East	1.16	1.08—1.24
South Asia	2.08	1.97—2.18
Sub-Saharan Africa	1.20	1.12—1.29
Western Europe & the US	1.71	1.11—2.32
FAMILY N= 416,317		
Caribbean	1.21	1.15—1.27
East Asia & the Pacific	0.71	0.69—0.73
Eastern Europe & Central Asia	0.76	0.72—0.80
Latin America	1.11	1.05—1.17
North Africa & the Middle East	0.86	0.80—0.92
South Asia	1.33	1.29—1.37
Sub-Saharan Africa	0.96	0.88—1.04
Western Europe & the US	0.71	0.66—0.76
ECONOMIC N= 585,539		
Caribbean	1.36	1.26—1.46
East Asia & the Pacific	0.65	0.64—0.66
Eastern Europe & Central Asia	0.68	0.66—0.70
Latin America	0.85	0.78—0.92
North Africa & the Middle East	0.79	0.75—0.83
South Asia	1.38	1.34—1.42
Sub-Saharan Africa	0.87	0.80—0.94
Western Europe & the US	0.54	0.50—0.58

* Adjusted HR of immigrant status*world region of origin interaction term obtained from the stratified multivariate models. These HRs are adjusted by age, sex, and neighborhood-level income quintiles.
* The immigrant*world region of origin interaction term compared immigrants to long-term Ontario residents. The reference category is the long-term Ontario residents when comparing the effect immigration within each immigrants' world region of origin.

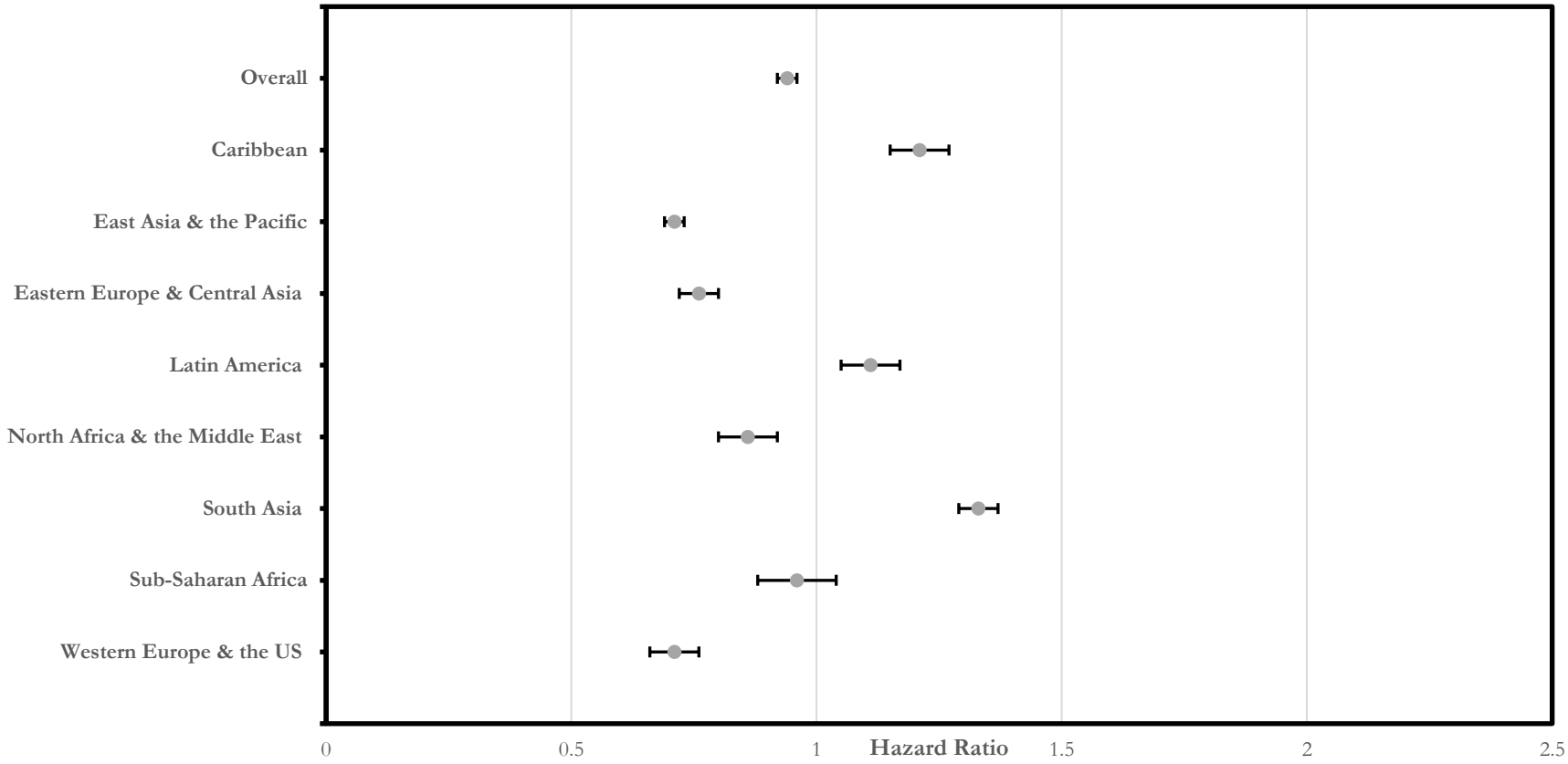
*The N size of long-term residents is equal to the N displayed for each immigrant category.

Figure 3.1 Adjusted Hazard Ratios for Refugees, by World Regions of Origin, compared to Long-term Residents of Ontario.



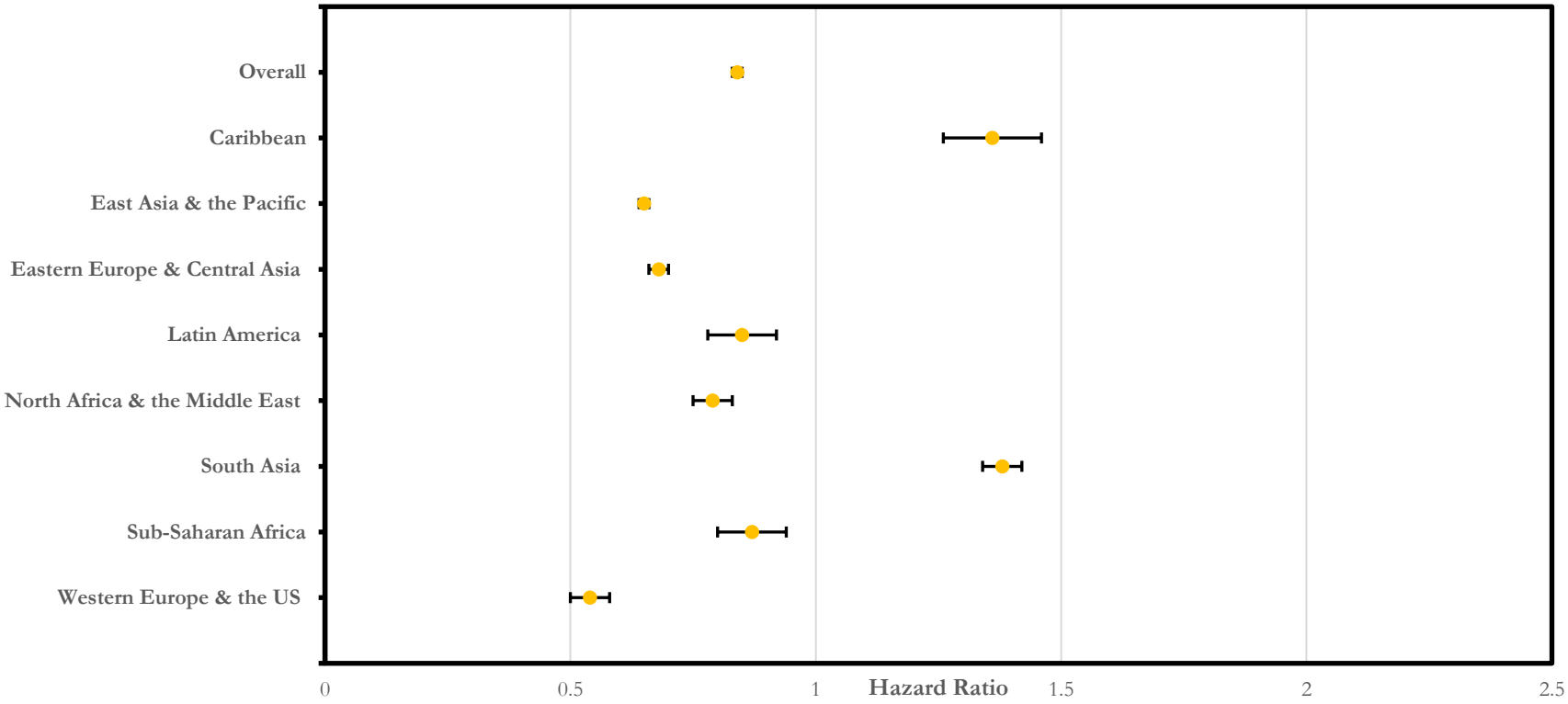
Adjusted by immigrant status*world region of origin interaction term, age, sex and neighborhood income

Figure 3.2 Adjusted Hazard Ratios for Family Immigrants, by World Regions of Origin, compared to Long-term Residents of Ontario



Adjusted by immigrant status*world region of origin interaction term, age, sex and neighborhood income

Figure 3.3 Adjusted Hazard Ratios for Economic Immigrants, by World Regions of Origin, compared to Long-term Residents of Ontario



Adjusted by immigrant status*world region of origin interaction term, age, sex and neighborhood income

Table 3.7 Hazard Ratios (HR) and 95% Confidence Intervals (C.I): Multivariate Cox Proportional Hazard Model of Multimorbidity (3+), by Immigrant Categories compared to Long-term Residents of Ontario.

	Immigrant Categories					
	Refugee N=151, 698		Family N=417, 422		Economic N=586, 560	
	Hazard Ratio	95% C.I.	Hazard Ratio	95% C.I.	Hazard Ratio	95% C.I.
Immigrant (Yes)	1.05	(0.99—1.11)	0.74	(0.72—0.76)	0.63	(0.61—0.65)
Age Category						
18-29 (reference)	—	—	—	—	—	—
30-44	3.60	(3.21—4.00)	3.53	(3.29—3.78)	3.53	(3.22—3.85)
45+	14.0	(12.4—15.6)	24.5	(23.0—26.0)	12.1	(11.0—13.3)
Sex						
Female	0.80	(0.75—0.85)	0.66	(0.64—0.68)	0.76	(0.74—0.78)
Male (reference)	—	—	—	—	—	—
Income Quintile						
Q1 (lowest income)	1.57	(1.39—1.76)	1.79	(1.70—1.88)	1.82	(1.72—1.92)
Q2	1.35	(1.20—1.51)	1.52	(1.44—1.60)	1.55	(1.46—1.65)
Q3	1.40	(1.24—1.57)	1.34	(1.27—1.41)	1.45	(1.37—1.54)
Q4	1.10	(0.96—1.25)	1.21	(1.15—1.27)	1.21	(1.13—1.28)
Q5 (reference)	—	—	—	—	—	—

*The N size of long-term residents is equal to the N displayed for each immigrant category.

Table 3.8 Adjusted Hazard Ratios (HR) and 95% Confidence Intervals (C.I) of developing Multimorbidity (3+) by World Regions of Origin, for Immigrant Categories, compared to long-term residents, 1995-2016.

Immigrant Categories World Region of Origin	Hazard Ratio	95% C.I.
REFUGEES N= 151,053		
Caribbean	1.21	0.68—1.73
East Asia & the Pacific	0.58	0.44—0.73
Eastern Europe & Central Asia	0.72	0.63—0.81
Latin America	0.59	0.48—0.71
North Africa & the Middle East	1.22	1.03—1.42
South Asia	1.78	1.59—1.98
Sub-Saharan Africa	0.99	0.83—1.15
Western Europe & the US	1.63	0.72—2.55
FAMILY N= 416,317		
Caribbean	0.96	0.86—1.06
East Asia & the Pacific	0.53	0.50—0.56
Eastern Europe & Central Asia	0.67	0.61—0.73
Latin America	0.86	0.77—0.95
North Africa & the Middle East	0.73	0.63—0.83
South Asia	1.08	1.02—1.14
Sub-Saharan Africa	0.74	0.62—0.86
Western Europe & the US	0.69	0.61—0.79
ECONOMIC N= 585,539		
Caribbean	1.07	0.92—1.22
East Asia & the Pacific	0.43	0.41—0.45
Eastern Europe & Central Asia	0.59	0.54—0.64
Latin America	0.74	0.62—0.86
North Africa & the Middle East	0.73	0.65—0.82
South Asia	1.04	0.98—1.12
Sub-Saharan Africa	0.69	0.55—0.83
Western Europe & the US	0.46	0.40—0.53

* Adjusted HR of immigrant status*world region of origin interaction term obtained from the stratified multivariate models. These HRs are adjusted by age, sex, and neighborhood-level income quintiles.
* The immigrant*world region of origin interaction term compared immigrants to long-term Ontario residents. The reference category is the long-term Ontario residents when comparing the effect immigration within each immigrants' world region of origin.

* The N size of long-term residents is equal to the N displayed for each immigrant category.

3.5 DISCUSSION

3.5.1 Main Findings

Our study showed an association between an immigrant's visa category, their world region of origin and multimorbidity risk in Ontario. This study is among the first to describe the incidence and patterns of multimorbidity among different immigrant populations compared to long-term residents in Ontario.

Our study examined the most prevalent multimorbidity dyads and triads, revealing several similarities and distinctions in the most common groups of chronic conditions prevalent across different immigrant populations and long-term residents of Ontario. Hypertension and diabetes, and its combination with COPD were the leading multimorbidity dyad and triad groups for all immigrant categories and long-term residents of Ontario. Several dyads and triads were more prevalent among long-term residents, while the prevalence of other disease groups varied by immigrant category.

We investigated the risk of having two or more and three or more co-occurring conditions, for each immigrant category, compared to long-term Ontario residents. Refugees had a higher risk of having two or more chronic conditions compared to long-term residents. The risk among refugees was highest compared to other immigrant categories. Our stratified analyses, by world region of origin, revealed sub-populations, within each immigrant category, that may be at greater risk of developing multimorbidity (two or more and three or more chronic conditions) when compared to long-term residents.

For example, immigrants from the Caribbean and South Asia had a greater risk, irrespective of their immigrant category. Immigrants from other world regions of origin (e.g., East Asia and the Pacific and Eastern Europe and Central Asia) had lower risk compared to long-term residents. Immigrants from certain world regions of origin had greater risk of multimorbidity that varied by their immigration category. For example, refugees from sub-Saharan Africa had a higher risk

compared to long-term residents, whereas family and economic class immigrants from the same world region had a lower risk.

When we examined the risk of developing three or more chronic conditions, our analyses identified refugee and family immigrants from South Asia and refugees from North Africa and the Middle East having a greater risk than long-term residents, surpassing the risk of immigrants from other world regions of origin.

To date, there has been limited population-based research on multimorbidity incidence among immigrants compared to native-born populations, and its associated risk across different immigrant populations. In Europe, a few emerging studies have investigated multimorbidity among immigrants using both registry-based and self-reported, cross-sectional data (Diaz, Kumar, et al., 2015; Diaz, Poblador-Pou, et al., 2015; Gimeno-Feliu et al., 2017; Lenzi et al., 2016; Taleshan et al., 2018).

Results from our study confirm findings from previous research that have investigated the relationship between immigrant categories and the risk of multimorbidity using population-based registry data in Europe (Diaz, Kumar et al. 2015; Taleshan et al., 2018).

In Norway, Diaz, Kumar, and colleagues (2015) used data from the National Population Register to estimate the prevalence of multimorbidity across immigrant groups (refugees, labour immigrants, family reunification immigrants and education immigrants). They reported an association between multimorbidity and migration, where the risk was higher among refugees and lower among labour and education immigrants compared to family reunification immigrants. Rates of multimorbidity doubled after a five-year stay in Norway for all immigrant groups. (Diaz, Kumar, et al., 2015).

In Denmark, a historical prospective study used data from the Danish National Patient Registry and the Danish Immigration Service to investigate multimorbidity and mortality among

refugees and family reunification immigrants from non-Western countries compared to Danish-born citizens (Taleshan et al., 2018). They found that refugees had higher risk of multimorbidity and family reunification immigrants had lower risk compared to Danish-born residents (Taleshan et al., 2018).

Diaz, Poblador-Pou and colleagues (2015) conducted a nation-wide multi register study in Norway using data from the National Population Register to examine the associations between multimorbidity and an immigrants' world region of origin compared to individuals born in Norway. Rates of multimorbidity were lower for immigrants from Eastern Europe, Asia, Africa and Latin America, Western-Europe and North America compared to Norwegian-born citizens (Diaz, Poblador-Pou, et al., 2015). In this study, they grouped immigrants from Asia, Africa, and Latin America together in one category, and did not examine immigrants by their immigration classification. However, they reported lower multimorbidity risk among immigrants originating from Eastern Europe, Western Europe, and North America; findings that are similar to our current study.

In Spain, Gimeno-Feliu and colleagues (2017) conducted a cross-sectional retrospective study of all adults eligible for public health service in Aragon, Spain to examine the associations with region of origin and length of residence in the host country among immigrants compared to individuals born in Spain. They reported that the risk of multimorbidity was lower among immigrants compared to native-born Spaniards but increased with longer duration in Spain. Rates of multimorbidity varied considerably depending on an immigrants' region of origin, but continued to remain lower compared to individuals born in Spain (Gimeno-Feliu et al., 2017).

A cross-sectional study on administrative data in Emilia-Romagna, Italy estimated the prevalence of multimorbidity by age, gender and citizenship and reported that multimorbidity was significantly more frequent among Italian citizens than among immigrants (Lenzi et al., 2016). In Canada, Roberts and colleagues (2015) reported lower odds of multimorbidity among immigrants,

compared to individuals born in Canada, using data from the Canadian Community Health Survey (Roberts et al., 2015). These studies did not distinguish between immigrants' visa category, had a much smaller sample size, and conducted cross-sectional data analysis with the inability to establish causal associations between being an immigrant and the risk of multimorbidity.

3.5.2 Strengths and Limitations of the Study

This study has several strengths including the use of large population-based data of eligible immigrants that landed in Canada between 1992 to 2010, limiting self-selection bias and enabling stratified analyses to compare immigrants to long-term residents by migration profile such as immigration visa category and world regions of origin.

We overcame previous methodological limitations by estimating the incidence of multimorbidity among a healthy cohort of immigrants in Canada. Previous research in Canada has largely focused on calculating the prevalence of multimorbidity, with limited ability to distinguish whether the co-occurring conditions existed prior to immigrating to Canada (Roberts et al., 2015).

Our study contained over twenty years of data to examine multimorbidity using nine chronic health conditions from ICES derived disease cohorts that have been defined from previously validated population-derived cohorts using linked data algorithms (Appendix E). Our use of large, population-based administrative data facilitated the ability to make evidence-informed policy and decision-making on the healthcare needs of immigrant populations, with various chronic conditions, and the extent to which the healthcare system can respond to such needs (Iron, Lu, Manuel, Henry, & Gershon, 2011).

In our study, we defined multimorbidity as two or more and three or more co-occurring chronic conditions. Methods for defining and measuring multimorbidity are evolving and no universal definition currently exists (Ryan et al., 2018; Smith, Soubhi, Fortin, Hudon, & O'Dowd, 2012b). Our use of administrative health data relied on the quality of the data recorded which is a

common limitation for studies that use routinely collected health information (Barnett et al., 2012; Diaz, Poblador-Pou, et al., 2015).

Our findings did not include several social determinants of health factors such as lifestyle, behavioural factors, barriers to care and health seeking behaviours. Our data contained migrant characteristics at the time of an immigrants' landing and included neighborhood-level income only 3-years following their landing. Our data may have also underestimated the immigrant populations' risk of developing multimorbidity, since most chronic condition algorithms used in the ICES-derived disease cohorts favor specificity over sensitivity (Appendix E). Additionally, mental health was not included as one of the co-occurring conditions since ICES-derived disease cohorts were not available for mental health conditions at the time of the study.

The latter limitation is particularly important to note since several studies have reported that immigrants, especially refugee populations, have a greater risk of experiencing adverse mental health outcomes both pre- and post- settlement in a host country (Beiser, 2005; Hyman, 2010; Rouhani, 2011; Mayhew et al., 2015).

Other studies have also reported an association between mental health conditions and multimorbidity (Barnett et al., 2012; Fortin et al., 2006; Gunn et al., 2012; Prior et al., 2016). Prior and colleagues (2016) investigated the association between perceived stress and mortality among individuals with multimorbidity using population-based data from the Danish National Health Survey and found an increasing dose-response pattern in mortality rates, and stress-associated death among people with multimorbidity.

To our knowledge, two other studies in Europe have examined multimorbidity patterns using mental health conditions as part of the examined chronic conditions among immigrants, compared to native-born individuals, and identified psychiatric disorders and mental health conditions among the most common conditions to co-occur with cardiovascular, respiratory and

endocrinological conditions (Diaz, Pobladou-Pou et al, 2015; Lenzi et al., 2016). These findings indicate the complexity of emerging patterns of multimorbidity for immigrants and non-immigrants when including a wide array of both mental and physical health conditions.

Various forms of mental health conditions, including stress, are also known to be associated with acculturative and migration stress, placing immigrant populations at greater risk (Djuric et al., 2010; APA, 2016).

Stress is considered a risk factor for several major chronic illnesses including cardiovascular disease, obesity, diabetes, depression, cognitive impairment, and inflammatory and autoimmune disorders, and has direct associations with injuries, and suicides as well as indirect associations with cancer and upper respiratory illnesses (APA, 2016; Djuric et al., 2010).

Mental health conditions are further associated with poor quality of life, adverse health outcomes, and mortality (Chandola, Brunner, & Marmot, 2006; Prior et al., 2016; Rosengren et al., 2004; Russ et al., 2012; Whiteford et al., 2013).

3.5.3 Study Implications and Future Directions for Policy and Program Planning

The incidence of multimorbidity is increasing in Canada due in part to an increased rate of individual chronic conditions such as diabetes and hypertension (Van Den Akker, Buntinx, Roos, & Knottnerus, 2001). Current medical guidelines in Canada are geared towards the care and management of patients with singular diseases. This imposes a challenge for primary health care professionals who try to implement evidence-based guidelines when providing care for patients with multimorbidity (Muggah et al., 2012).

Findings from this study highlight the need to better understand both the clinical and healthcare system impacts of multimorbidity to inform the development of guidelines and standards of care, including improvements of existing health care programs and services for patients with multimorbidity (Muggah et al., 2012).

This study further highlights the importance of examining the intersecting factors that impact and differentiate the health of immigrant populations. We classified immigrants by their immigration category and world region of origin to investigate pre-migratory differences of immigrants, as conceptualized in our understanding and application of the CSDH framework to identify sub-populations at greater risk of multimorbidity.

The primary health care system plays a critical role in the management of chronic conditions, including health promotion and disease prevention across various population groups (Muggah et al., 2012). The rising number of multiple chronic conditions will have significant financial and system-wide impacts relevant to primary health care policy and practice (Muggah et al., 2012). It is important to develop preventative measures, through the implementation of integrated health models, as well as designing health promotion initiatives, that are culturally sensitive and tailored to different populations (Diaz, Ortiz-Barreda et al, 2017; Iron et al., 2011; Muggah et al., 2012).

Our study also revealed emerging patterns of multimorbidity among long-term residents and different immigrant populations. Our findings can inform future strategies to providing more efficient, coordinated, and cost-effective care that would improve quality of life and reduce hospitalizations (Agborsangaya et al., 2013; Muggah et al., 2012; Boyd and Fortin, 2010). Future studies should examine the impact of common treatments and program initiatives on multimorbidity outcomes, across different populations, in order to identify best practices and opportunities for further research and development (Diaz, Ortiz-Barreda et al, 2017; Iron et al., 2011).

Addressing multimorbidity will also require efforts across all levels of government that include improving programs and policies that extend beyond the healthcare system, such as social services as well as settlement and integration policies tailored for immigrant sub-populations at greater risk, such as refugees and immigrants from various world regions of origin. Such an

integrated approach will enable policy and program planners to tackle and address health inequities that stem from the structural and intermediary determinants that impact health and well-being across the immigrant population. As such, routine population-based data collection on immigration status and ethnicity/region of origin is critical to help inform research, policy development, interventions and decision-making that impact long-term investments in preventive health services and management of multimorbidity.

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CHAPTER 4 - COHORT AND MIGRATION PATTERNS: COMPARING TRENDS IN CHRONIC CONDITION OUTCOMES AMONG IMMIGRANT POPULATIONS IN CANADA

ABSTRACT

Background: The healthy immigrant effect has been documented in several immigrant-receiving countries, and is influenced by age, period and cohort effects. The impact of cohorts on immigrant health has varied based on study design, the outcome examined and the specific immigrant study population. No study to date has examined the impact of cohort characteristics on health outcomes across different immigrant populations using population-based longitudinal data in Canada. This study examined cohort differences in chronic condition outcomes across different immigrant populations compared to long-term residents of Ontario.

Methods: This study used a 1:1 matched retrospective observational cohort design and included an open cohort of individuals entering the study, at different points in time, from 1995 to 2016, using routinely collected population-based administrative data at ICES. Our outcome variable consisted of the incidence of at least one of nine chronic conditions (asthma, Chronic Obstructive Pulmonary Disease, rheumatoid arthritis, acute myocardial infarction, congestive heart failure, diabetes, Crohn's and colitis disease, cancer, and hypertension) defined from previously validated ICES-derived disease cohorts. We used an immigrants' year of landing to create five distinct landing cohorts of immigrants between 1992-1995, 1996-1999, 2000-2003, 2004-2007, and 2008-2010. Period-cohort effects were studied by calculating incidence rates for each immigrant category and long-term resident of Ontario in specific time-intervals by landing cohort. The risk for developing a chronic condition was calculated using stratified Cox Proportional Hazard models, by landing cohort and immigrant visa category, for all immigrants and long-term residents.

Results: A total of 2,312,244 immigrants and long-term Ontario residents were included in the study. The risk for developing a chronic condition increased in more recent cohorts, for all immigrant categories, and was highest among refugees. The risk of developing a chronic condition across each landing cohort did not considerably change over time for refugees and family immigrants but decreased for economic class immigrants, with time spent in Canada. After controlling for age, sex, neighborhood level income quintiles and world regions of origin, the risk of developing a chronic condition was higher among refugees, compared to long-term residents and was highest among refugees who landed between 2008-2010 compared to refugees in earlier landing cohorts (HR 2008-2010: 1.47 95% CI [1.25 – 1.69] vs. HR 1992-1995: 1.00 95% CI [0.84 – 1.16]). The risk of having a chronic condition was lower among family and economic class immigrants, when compared to long-term residents, irrespective of their landing cohort.

Conclusions: Findings from this study highlight the need to consider cohort effects in chronic disease incidence research, policy and program development. Future research should further examine the impact of immigrant cohorts to better identify strengths and opportunities in the context of immigration policy and settlement.

4.1 INTRODUCTION

4.1.1 Background

Many studies in the literature have reported that immigrants enjoy better health than non-immigrants, but that their health declines with duration of residence in the host country and converges to, and sometimes becomes worse, than the health of non-immigrants. This 'healthy immigrant effect' has been documented in several immigrant-receiving countries (Fredericks & Guruge, 2015; Kennedy, Kidd, McDonald, & Biddle, 2015; Moullan & Jusot, 2014; Ro, Geronimus, Bound, Griffith, & Gee, 2015; Rote & Markides, 2015). Factors contributing to the healthy immigrant effect are complex and include selective immigration policies, access to health care, and acculturation (Constant, 2017; Antecol & Bedard, 2015; Kennedy, Kidd, McDonald, & Biddle, 2015; Moullan & Jusot, 2014).

More recent evidence suggests that the healthy immigrant effect is not always consistent when health outcomes are examined across different sociodemographic groups (Gee, Kobayashi, & Prus, 2004; Kobayashi & Prus, 2012; Oza-Frank & Venkat Narayan, 2010). Factors such as gender, race, ethnicity, type of immigrant and age at time of arrival can impact health outcomes following settlement in a host country (Constant, 2017; Antecol & Bedard, 2015).

The healthy immigrant effect is further influenced by age, period, and cohort effects, since health is influenced by several social and physical environmental factors (Constant, 2017). Age reflects variations in disease across age groups linked to physical and biological changes and is unrelated to the period or year of birth to which an individual belongs to (Reither et al., 2009; Constant, 2017; Columbia University, n.d). Period effects represent environmental, social, and economic changes, occurring over time, affecting all age groups, such as that observed following a change in health policy, war, economic crisis, or other contextual factors (Keyes & Li, 2012). Cohort effects are variations in the distribution of disease that result from the unique experience or

exposure in a group of subjects (cohort) as they move across time (Keyes et al., 2010). Among immigrants, cohort effects can be examined as differences in the likelihood of an outcome occurring for immigrants arriving at different years (Antecol & Bedard, 2015; Constant, 2017; Giuntella & Stella, 2017; Creatore, 2013). The consideration of potential cohort effects is important to not overestimate the declining rate of immigrant health outcomes over time (Hamilton et al., 2015).

The impact of cohorts on the health of immigrants have been explored in the United States where significant cohort differences have been reported in immigrant health post-settlement. Results have varied based on the outcome measure examined, the study design, and immigrant study population (Antecol & Bedard, 2006; Hamilton and Hummer, 2011; Giuntella & Stella, 2017; Ro, Geronimus, Bound, Griffith, & Gee, 2015). For example, Hamilton and Hummer (2011) reported that earlier cohort of immigrants from the Caribbean had better self-reported health than cohorts who immigrated to the US in later years. Similarly, Antecol and Bedard (2006) reported declining baseline health among immigrants who arrived in later cohorts. Ro and colleagues (2015) investigated cohort and duration patterns in obesity and self-rated health among Asian immigrants in the US. More recent Asian immigrants had better self-rated health at the time of arrival compared to the initial health status of older cohorts of Asian immigrants (Ro et al., 2015). Another study explored cohort differences in obesity and rates of obesity assimilation in the United States and reported significant differences among immigrants arriving in different cohorts (Giuntella & Stella, 2017).

In Canada, Creatore and colleagues (2013) reported cohort effects in diabetes diagnosis among immigrants in Ontario. They reported that immigrants who arrived in more recent landing cohorts were at a higher risk of being diagnosed with diabetes than earlier cohorts for both women and men (Creatore, 2013).

Previous studies that have examined cohort effects in the immigration population have treated immigrants as a homogenous group, without distinguishing disparities across different immigrant categories, or have utilized self-reported or cross-sectional data with the inability to establish causal relationships (Antecol & Bedard, 2015; Constant, 2017; Giuntella & Stella, 2017; Ro et al., 2015).

To our knowledge, no other studies have extensively examined the impact of cohorts on health outcomes across different immigrant populations, using population-based longitudinal data in Canada. This study addresses some of these existing knowledge gaps by utilizing population-based immigrant and health data available at ICES.

4.1.2 Objective

The main objective of this study is to examine cohort differences in chronic condition outcomes among different immigrant populations compared to long-term residents of Ontario.

4.2 METHODOLOGY

4.2.1 Ethics

Ethics approval was obtained from the University of Ottawa Health Science and Science Research and Ethics Board. No patients were recruited for the study. This study used de-identified population-based health administrative data at ICES. ICES is an independent, non-profit research institute funded by an annual grant from the Ontario Ministry of Health and Ministry of Long-Term Care (MOH and MLTC). As a prescribed entity under Ontario's privacy legislation, ICES is authorized to collect and use health care data for the purposes of health system analysis, evaluation, and decision support. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario.

4.2.2 Study Design, Setting and Data Sources

This study used a matched retrospective cohort design from 1995 to 2016. It included an open cohort of individuals entering the study, at different points in time, using routinely collected administrative data at ICES. ICES holds data on patient socio-demographic and economic information, healthcare utilization, immigration data and medical profiles for individuals eligible for universal health coverage in Ontario. Multiple datasets held at ICES were utilized in this study. They were linked using unique encoded identifiers and analyzed at ICES. The Registered Persons Database (RPDB) was used to identify eligible long-term residents. The RPDB is an electronic registry of all individuals eligible for health coverage in Ontario. The Immigrant and Refugees Citizenship Canada Permanent Residents Database (IRCC) was used to identify immigrants. The IRCC database is a registry of all landed immigrants to Canada since 1985 containing individual-level information of all immigrants, at the time of landing, who identified Ontario as a declared destination. We used the Ontario Health Insurance Plan Billing Data (OHIP) which is the provincial health program database providing publicly funded universal health services through the Ontario Ministry of Health and Ministry of Long-Term Care to approximately 95% of Ontario residents [15]. The OHIP database was used to identify immigrants and long-term residents who have had an interaction with the healthcare system. We also used CENSUS data and Postal Code Conversion

[15] OHIP does not cover health services for First Nation populations on reserves and members of the Armed Forces who receive health coverage through other federally funded programs. ICES contains most claims paid for by OHIP covering all health care providers who can claim under OHIP. This includes physicians, groups, laboratories, and out-of-province providers (ICES, 2017).

Files (PCCF+)[16] to collect sociodemographic information and geographic area of residence based on urban and rural geographic areas.

The following ICES Derived Disease Cohorts were used to capture diagnoses of chronic conditions: the Ontario Asthma Dataset (Gershon, Wang, Guan, Frcpc, et al., 2009; Gershon, Wang, Guan, Vasilevska-Ristovska, et al., 2009; To et al., 2006), Ontario Congestive Heart Failure Dataset (Schultz, Rothwell, Chen, & Tu, 2013), Ontario Chronic Obstructive Pulmonary Disease dataset (Gershon, Wang, Guan, Vasilevska-Ristovska, et al., 2009), Ontario Hypertension Dataset (Tu, Campbell, Chen, Cauch-Dudek, & McAlister, 2007; Tu, Chen, & Lipscombe, 2008), Ontario Crohn's and Colitis Cohort Dataset (Benchimol et al., 2009; Benchimol et al., 2014), the Ontario Diabetes Dataset (Guttmann et al., 2010; Lipscombe et al., 2018), the Ontario Myocardial Infarction Dataset (Austin, Daly, & Tu, 2002), the Ontario Rheumatoid Arthritis Dataset (Widdifield et al., 2013, 2014), and Cancer records from the Ontario Cancer Registry (ICES, 2018). These conditions have been defined from previously validated population-derived ICES cohorts using linked data algorithms derived from health administrative data held at ICES (Appendix E).

4.2.3 Participants

We identified immigrants who landed to Ontario between 1992 and 2010 and were 18 to 70 years of age on the year of landing. Immigrants must have resided in Ontario for at least three years following their landing year, obtained OHIP coverage during that time, and have had no documentation of any of the nine chronic conditions that can be ascertained with the ICES-derived

[16] Census and PCCF+ data for 1996, 2001, 2006 and 2011 were used based on the index year for which immigrants and long-term residents entered the study (ICES, 2013).

disease cohort data on December 31, three years following their arrival. We used a three-year period to allow enough time for immigrants to obtain OHIP coverage and have an interaction with the health care system. We included only immigrants with an immigration visa entry classified as a refugee, family, or economic category (over 97% of all immigrants) (Appendices A and B).

Once eligible immigrants were identified, a long-term resident of Ontario was matched 1:1 to each immigrant by age, sex, and rurality (Rurality Index of Ontario (RIO)>45 (yes/no) (using RPDB and PCCF+ data files) at the time of eligibility (three years after landing).

Long-term Ontario residents must have resided in Ontario for at least ten years prior to the year of matching, been disease-free from all the ICES-derived disease cohorts on December 31 of the year of matching, and not included in the IRCC database at any point in time (Appendices A and B). The long-term Ontario residents are mostly born in Canada but may include immigrants who have settled in Ontario before 1985. Since we only have OHIP records from 1991 onwards, we cannot ascertain OHIP eligibility from birth for those born prior to 1991. To avoid potential misclassification of immigrants as long-term residents, individuals in the long-term Ontario resident cohort must have had an Ontario postal code before January 1, 1994, must have had OHIP eligibility from 1991 to 1994 and not be in the IRCC database at any time simultaneously.

Only matched long-term residents were retained; all other long-term Ontario residents were removed from the dataset. The matched cohort was then linked to the other datasets at ICES.

4.2.4 Variables

Outcome Variable

Our primary outcome consists of the incidence of any of the nine chronic health conditions captured in the ICES derived disease cohorts. These chronic conditions were the only validated ICES-derived disease cohorts available at the time of the study.

Independent Variables

We used both sociodemographic and immigration variables in our analyses available from linking multiple datasets at ICES (Appendix F). We were interested in whether an individual was an immigrant (yes/no) belonging to one of the three immigrant categories (refugee, family, or economic immigrant) as our primary covariate. Our sociodemographic variables included age (categorized as 18-29, 30-44, 45+), sex (Male/Female) and neighborhood level income quintiles (Q1-Q5) derived from the ICES-linked datasets[17].

Our immigration variables were directly derived from the IRCC database and contained individual-level data on an immigrants' visa category (Refugee, Family, Economic - refer to Appendix C for a list of how immigrant categories were grouped using data from the Immigration, Refugee and Citizenship Canada Landed Immigrant Dataset), country of origin, their year of landing in Ontario, level of education (Secondary or less, Non-University Qualifications/Some University, University degree or higher) and official language proficiency (English, French or both) at the time of their landing. We used the country-of-origin data to derive a world region of origin variable. The IRCC database included immigrants from over 200 different countries. We grouped countries into world regions of origin based on the World Bank schema and further by ethnic grouping (Creatore, 2013) to obtain the following categories: the Caribbean, East Asia and the Pacific, South Asia, Eastern

[17] Age and sex were derived from administrative health records. Neighborhood level income was used since individual-level data was not available and was derived from postal code conversion files using the Census area profiles described in paper 1. Residential postal code for an individual was linked to dissemination- level income data collected for the 1996, 2001, 2006 and 2011 Canadian census using the PCCF+ files which corresponded to their respective Census files.

Europe and Central Asia, North Africa and the Middle East, Latin America, Western Europe and the US, and sub-Saharan Africa (Appendix D).

Our study population consisted of multiple waves of immigrants arriving in different years, at different ages, and born in different time periods. To account for potential age-period-cohort differences, immigrants were grouped by their year of arrival to Canada, in addition to stratifying the analyses by age categories. This method has been previously applied in studies using ICES data (Creatore, 2013). We used an immigrants' year of landing in Ontario to create five distinct landing cohorts of immigrants – those landing between 1992-1995, 1996-1999, 2000-2003, 2004-2007, and 2008-2010. The categorization of landing cohorts was arbitrary and of the same interval, except for the 2008-2010 group.

4.2.5 Statistical Methods

Descriptive Analysis

We first examined the distribution of socio-demographic (age, sex, neighborhood income quintiles) and immigrant-specific characteristics (world regions of origin, immigrant category, education, and language proficiency) for immigrants by their landing cohort (n%).

Disease-free immigrants and long-term residents were followed forward in time from study start date (baseline) to last follow-up (diagnosis of a chronic condition, death, loss of OHIP eligibility, or end of the study observation period). We calculated the risk for developing a chronic condition, by landing cohort, for all immigrants and long-term resident during the study observation period of 1995 to 2016. We defined risk as the number of events (a diagnosis of one out of the nine chronic conditions)/1000 person-years. We estimated the unadjusted relative risk, per 1000 person-years, for each landing cohort, stratified by immigrant category (refugees, family, economic) and compared to long-term residents. For all analyses, we examined the effect of immigration on the development of a chronic condition, stratified by immigrant visa category, to account for the

heterogeneity among immigrant populations, as conceptualized by the CSDH framework on the social determinants of health and described in chapters 2 and 3.

We also examined period-cohort effects by calculating incidence rates for each immigrant category and long-term resident of Ontario between 1996-1999, 2000-2003, 2004-2007, 2008-2010 and 2011-2016 by landing cohort. For each landing cohort, we calculated the relative risk of immigrants developing a chronic condition, in each subsequent time-period, compared to long-term residents. The relative risk for each landing cohort was stratified by immigrant category and compared to long-term residents.

Regression modelling

We used Cox Proportional Hazard Models to examine the risk over time for developing a chronic condition by landing cohort. Disease-free immigrants and long-term residents were followed from baseline to event (diagnosis of a chronic condition) or last follow-up. Individuals for whom death, loss of OHIP eligibility or the end of the study observation period occurred before the event were censored at that date.

We examined the risk of developing a chronic condition across different strata of immigrant populations when compared to long-term residents of Ontario by an immigrants' landing cohort. Based on existing research, we hypothesized there are differences in the effect size of being an immigrant and how they experience chronic health outcomes, by their landing cohort when comparing their risk to long-term residences.

We first calculated the unadjusted hazard ratios (HR) and 95% confidence intervals (CI) for our outcome using an interaction term for immigrant status (yes/no) and landing cohort (1992-1995, 1996-1999, 2000-2003, 2004-2007, 2008-2010) to estimate the risk for immigrants, by their landing cohort, when compared to long-term residents. The unadjusted HRs were further stratified by age categories as well as by an immigrants' world regions of origin.

Each long-term resident was assigned the same migrant characteristics (e.g., immigrant visa category) as their matched immigrant counterpart to enable comparisons using the same sample that did the 1:1 matching, when comparing the effect of immigration on the risk of developing a chronic condition, for different strata of immigrants. The long-term residents were also categorized in the same landing cohort as their matched immigrants.

We built three stratified multivariate models, by immigrant visa category, to estimate the HR and 95% CI for developing a chronic condition. Each multivariate model was adjusted by age, sex, neighborhood income quintiles, world regions of origin and an interaction term for immigrant status*landing cohort to estimate the risk for immigrants, within each landing cohort, compared to long-term residents[18] depicted in the following formula as:

Chronic Condition Outcome= Immigrant (yes/no) Age Category + Sex + Neighborhood level income +World Region of Origin + Immigrant (yes/no)*Landing Cohort

For each stratified immigrant visa category model, we estimated effect sizes for the landing cohort interaction term by calculating the beta for immigrants and long-term residents for each landing cohort category as:

- Beta immigrant: Sum of the coefficient for immigrant (yes) + landing cohort+ immigrant (yes)*landing cohort.

[18] We did not perform a matched analysis on the data. The multivariate models adjusted for age and sex, which were variables used in the study design to match immigrants and long-term residents. This adjustment of matching variables in the multivariate models is a method that has previously been used on matched cohort data (Sjölander & Greenland, 2013). Appendix G provides a detailed discussion on the rationale for using this analytic approach.

- Beta long-term resident: landing cohort

We then obtained the Hazard score for immigrants and long-term residents as exp(beta) and calculated the Hazard Ratio for each immigrants' landing cohort (Hazard [immigrants]/Hazard [long-term residents]).

All analyses were conducted with SAS software, version 9.4 (SAS Institute Inc., Cary, NC).

4.3 **RESULTS**

Between 1992 to 2010, a total of 2,037,657 immigrants landed in Ontario. Of these, 1,156,122 were disease-free and continued to reside in Ontario three years after landing. Each immigrant was matched to a long-term resident, resulting in a total of 2,312,244 individuals, entering the cohort at different points in time, that were followed forward until December 31, 2016. The total follow-up duration was 11,490,141 and 11,424,318 person-years in the immigrant and long-term resident group, respectively.

Table 4.1 shows the distribution of sociodemographic variables and migration characteristics of immigrants, across each landing cohort, in the study population (n%). Between 1992 to 2010, there was variability in the distribution of immigrant categories across landing cohorts. The proportion of economic immigrants increased from 29.2% in 1992-1995 to 58.6% in 2000-2003 and decreased but remained consistent in more recent landing cohorts (50.8% in 2008-2010). There was variability in the proportion of refugee and family immigrants across landing cohorts. Refugees comprised the lowest proportion of immigrants, across all landing cohorts, followed by family immigrants. Among refugees, the proportions were lowest in 1996-1999 (11.5%) and 2000-2003 (10.2%). Among family immigrants, the lowest proportions were 32.9% and 31.2% in 1996-1999 and 2000-2003 respectively. In 2008-2010, there were 11.8% refugees compared to 16.3% in 1992-1995. Among family immigrants, there were 36.1% in 2008-2010 compared to 44.4% in 1992-1995.

The proportion of immigrants who spoke English, French or both (yes/no), varied across landing cohorts and was highest in 2008-2010 (80.8%). The proportion of immigrants with a University degree or higher upon landing increased by from 20.5% to 51.3% between 1992 to 2003 with a slight decrease in 2004-2007 (46.7%) and 2008-2010 (48.4%).

Most immigrants came from East Asia and the Pacific and South Asia. There was variability, by world regions of origin, across different landing cohorts. For example, the proportion of immigrants from East Asia and the Pacific decreased by 4.6% from 1992-1995 (33.4%) to 2008-2010 (28.8%). Similarly, the proportion of immigrants from Eastern Europe and Central Asia decreased by 7% from 1992-1995 (14.2%) to 2008-2010 (7.2%). The proportion of immigrants from South Asia increased from 17.5% in 1992-1995 to 27.3% in 2008-2010. There was also an increase in the proportion of immigrants from North Africa and the Middle East increased by 5.7% between 1992-1995 (7.2%) to 2008-2010 (12.9%). There were no considerable changes across other world regions of origin (Figure 4.1).

There was a shift in the distribution of neighborhood income quintiles. The proportion of immigrants in the lowest (Q1 and Q2) neighborhood income quintiles decreased in more recent cohorts, with an increase among those in the highest income categories (Q3-Q5), as depicted in Figure 4.2.

Table 4.2. summarizes the number of and rate of a chronic condition occurrence by immigrant landing cohort for each immigrant category and long-term Ontario residents. Table 4.3 shows the unadjusted relative risk of developing chronic condition, by landing cohort, for each immigrant category, compared to long-term residents, during the observation period of 1995-2016. For all immigrant categories, the risk of having a chronic condition increased across each landing cohort when compared to long-term residents (Figure 4.3). The risk was most elevated among immigrants who landed in more recent cohorts and was highest among refugees (relative risk for

refugees who landed in 1992-1995: 1.16 [1.13 – 1.19] vs relative risk for refugees who landed in 2008-2010: 1.65 [1.50 – 1.80]).

Because the relative risk increased consistently with later landing cohorts, when compared to long-term residents, we examined whether this was due to a higher likelihood of immigrants having the outcome in the early cohorts following their landing, and a decline after (period effects), or whether the increased risk was related to cohort effects of immigrants of different landing cohorts.

Table 4.4 shows the relative risk of developing a chronic condition for each landing cohort, stratified by immigrant category, compared to long-term residents between 1996-1999, 2000-2003, 2004-2007, 2008-2010 and 2011-2016. Across each landing cohort, the risk of developing a chronic condition increased with more recent cohorts (for all immigrant categories) and was the highest among refugees. Over time, the risk across each landing cohort did not considerably change for refugees and family immigrants (except in the earlier years for family immigrants who landed between 1992-1995) but decreased for economic class immigrants with time spent in Canada (except for the 1992-1995 cohort), as depicted in Figures 4.4-4.6.

Table 4.5 shows the unadjusted HR and 95% CI of having a chronic condition, by landing cohort, and further stratified by age, for each immigrant category compared to long-term residents. For each age category, the risk of developing a chronic condition increased in more recent landing cohorts and was highest in 2008-2010 when comparing each immigrant category to long-term residents (Table 4.5). Among refugees, the risk increased among more recent cohorts, in all age categories, compared to long-term residents, and was the highest among those who were 44 years of age and older (Figure 4.7). The risk increased in more recent landing cohorts for family class immigrants between 18 to 29 and 44 years of age and older, but not substantially for those who were 30 to 44 years of age (Figure 4.8). Among economic class immigrants, the risk increased across each

subsequent landing cohort for each age category but remained lower than long-term residents for those who arrived on or before 2000-2003. Economic class immigrants who landed after 2004 had a higher risk, irrespective of their age group, when compared to long-term residents (Figure 4.9).

The unadjusted HR and 95% CI for each landing cohort stratified by world regions of origin is shown in Table 4.6. The risk, by world regions of origin, increased in more recent landing cohorts, and was the highest among immigrants from South Asia, sub-Saharan Africa and the Caribbean for all immigrant categories compared to long-term residents (Figures 4.10-4.12).

Table 4.7 displays the adjusted HRs obtained from the multivariate Cox Proportional Hazard models using the immigrant*landing cohort interaction term. The complete multivariate model outputs are provided in Appendix J. The HRs for the landing cohort interaction term shows that the risk was highest among refugees who landed between 2008-2010 compared to long-term residents, as opposed to refugees in earlier landing cohorts (HR 2008-2010: 1.47 95% CI [1.25 – 1.69] vs. HR 1992-1995: 1.00 95% CI [0.84 – 1.16]).

The risk of having a chronic condition was lower among family and economic class immigrants, when compared to long-term residents, irrespective of their landing cohort. However, their risk, among recent landing cohorts, was higher as opposed to family and economic class immigrants who landed in earlier cohorts (Figure 4.13).

The adjusted models showed an elevated risk among individuals in the lowest (Q1) neighborhood income quintile groups compared to those in the highest groups (Q5), older age categories compared to those 18-29 years of age, and a lower risk among females compared to males. The risk was higher among immigrants who came from the Caribbean and South Asia, compared to long-term residents, irrespective of their immigration category. The risk varied, by other world regions of origin, when examined across different immigrant categories.

4.4 TABLES AND FIGURES

Table 4.1 Distribution of sociodemographic and migration profile of immigrants across landing cohorts (n %)

	1992-1995		1996-1999		2000-2003		2004-2007		2008-2010		Total	
N	**259,637**		**213,128**		**273,368**		**249,760**		**160,229**		**1156,122**	
IMMIGRANT CATEGORY												
Refugee	42,361	(16.3)	24,509	(11.5)	28,007	(10.2)	38,091	(15.2)	18,858	(11.8)	151,826	(13.1)
Family	115,255	(44.4)	70,173	(32.9)	85,282	(31.2)	88,981	(35.6)	57,871	(36.1)	417,562	(36.1)
Economic	102,021	(39.2)	118,446	(55.6)	160,079	(58.6)	122,688	(49.1)	83,500	(52.1)	586,734	(50.8)
AGE CATEGORY												
18-29	74,925	(28.9)	53,767	(25.2)	65,664	(24.0)	69,178	(27.7)	42,930	(26.8)	306,464	(26.5)
30-44	131,662	(50.7)	120,107	(56.4)	159,472	(58.3)	132,718	(53.1)	83,959	(52.4)	627,918	(54.3)
45+	53,050	(20.4)	39,254	(18.4)	48,232	(17.6)	47,864	(19.2)	33,340	(20.8)	221,740	(19.2)
SEX												
Female	136,100	(52.4)	109,561	(51.4)	142,924	(52.3)	136,804	(54.8)	88,996	(55.5)	614,385	(53.1)
Male	123,537	(47.6)	103,567	(48.6)	130,444	(47.7)	112,956	(45.2)	71,233	(44.5)	541,737	(46.9)
INCOME QUINTILE												
Q1 (lowest income)	97,842	(37.8)	77,398	(36.3)	90,600	(33.2)	74,556	(30.0)	43,814	(27.4)	384,210	(33.2)
Q2	60,183	(23.2)	46,517	(21.8)	59,024	(21.6)	52,178	(20.9)	31,358	(19.6)	249,260	(21.6)
Q3	42,512	(16.4)	35,246	(16.5)	48,870	(17.9)	46,955	(18.8)	30,555	(19.1)	204,138	(17.7)
Q4	32,518	(12.6)	30,711	(14.4)	45,013	(16.5)	45,387	(18.2)	31,138	(19.4)	184,767	(16.0)
Q5	26,080	(10.1)	23,209	(10.9)	29,832	(10.9)	30,652	(12.3)	23,334	(14.6)	133,107	(11.5)
LANGUAGE PROFICIENCY												
Yes	173,363	(66.8)	148,194	(69.5)	176,584	(64.6)	183,809	(73.6)	129,519	(80.8)	811,469	(70.2)
No	86,256	(33.2)	64,934	(30.5)	96,784	(35.4)	65,951	(26.4)	30,710	(19.2)	344,635	(29.8)
EDUCATION LEVEL												
Secondary or less	129,260	(49.8)	71,544	(33.6)	73,551	(26.9)	72,463	(29.0)	44,276	(27.6)	391,094	(33.8)
Non-University Qualifications/Some University	77,083	(29.7)	57,196	(26.8)	59,648	(21.8)	60,573	(24.3)	38,443	(24.0)	292,943	(25.3)
University degree or higher	53,294	(20.5)	84,388	(39.6)	140,169	(51.3)	116,724	(46.7)	77,510	(48.4)	472,085	(40.8)

Table 4.1 Distribution of sociodemographic and migration profile of immigrants across landing cohorts (n %)

	1992-1995		1996-1999		2000-2003		2004-2007		2008-2010		Total	
WORLD REGION OF ORIGIN												
Caribbean	18,191	(7.0)	10,055	(4.7)	9,073	(3.3)	7,914	(3.2)	6,696	(4.2)	51,929	(4.5)
East Asia & the Pacific	86,251	(33.4)	60,504	(28.4)	76,773	(28.1)	67,844	(27.2)	45,940	(28.8)	337,312	(29.2)
Eastern Europe & Central Asia	36,675	(14.2)	34,614	(16.3)	38,916	(14.2)	27,839	(11.2)	12,162	(7.2)	150,206	(13.0)
Latin America	18,926	(7.3)	9,739	(4.6)	12,864	(4.7)	16,758	(6.7)	10,570	(6.6)	68,857	(6.0)
North Africa & the Middle East	18,632	(7.2)	19,785	(9.3)	24,292	(8.9)	25,929	10.4)	20,524	(12.9)	109,162	(9.4)
South Asia	45,342	(17.5)	55,531	(26.1)	86,055	(31.5)	74,709	(30.0)	43,589	(27.3)	305,226	(26.4)
Sub-Saharan Africa	16,451	(6.4)	10,489	(4.9)	13,327	(4.9)	14,712	(5.9)	9,220	(5.8)	64,199	(5.6)
Western Europe & US	17,890	(6.9)	12,162	(5.7)	11,881	(4.4)	13,437	(5.4)	10,889	(6.8)	66,259	(5.7)

Figure 4.1 Distribution of Immigrants by World Region and Landing Cohort.

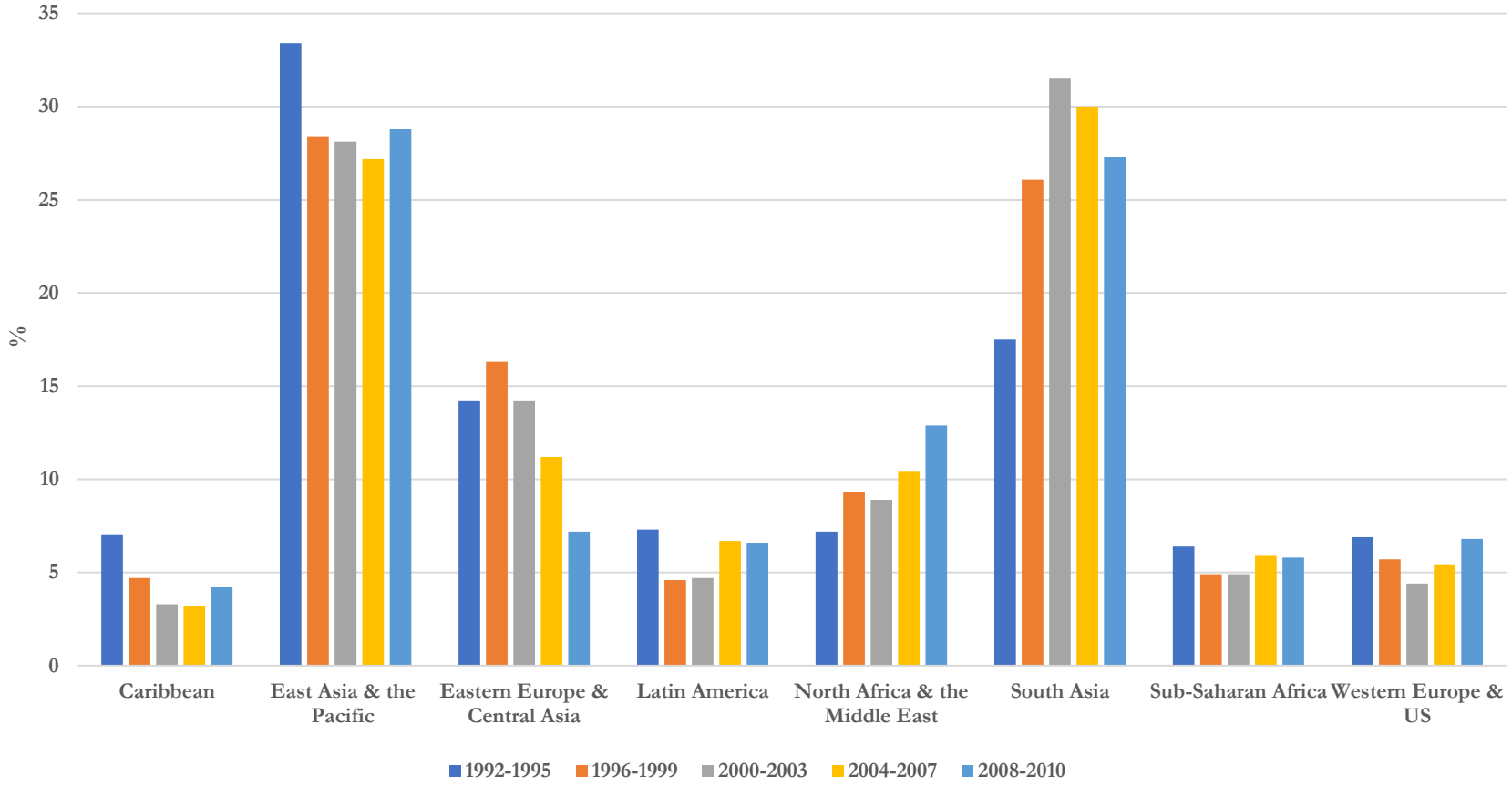


Figure 4.2 Distribution of Neighborhood Income Quintiles by Landing Cohort.

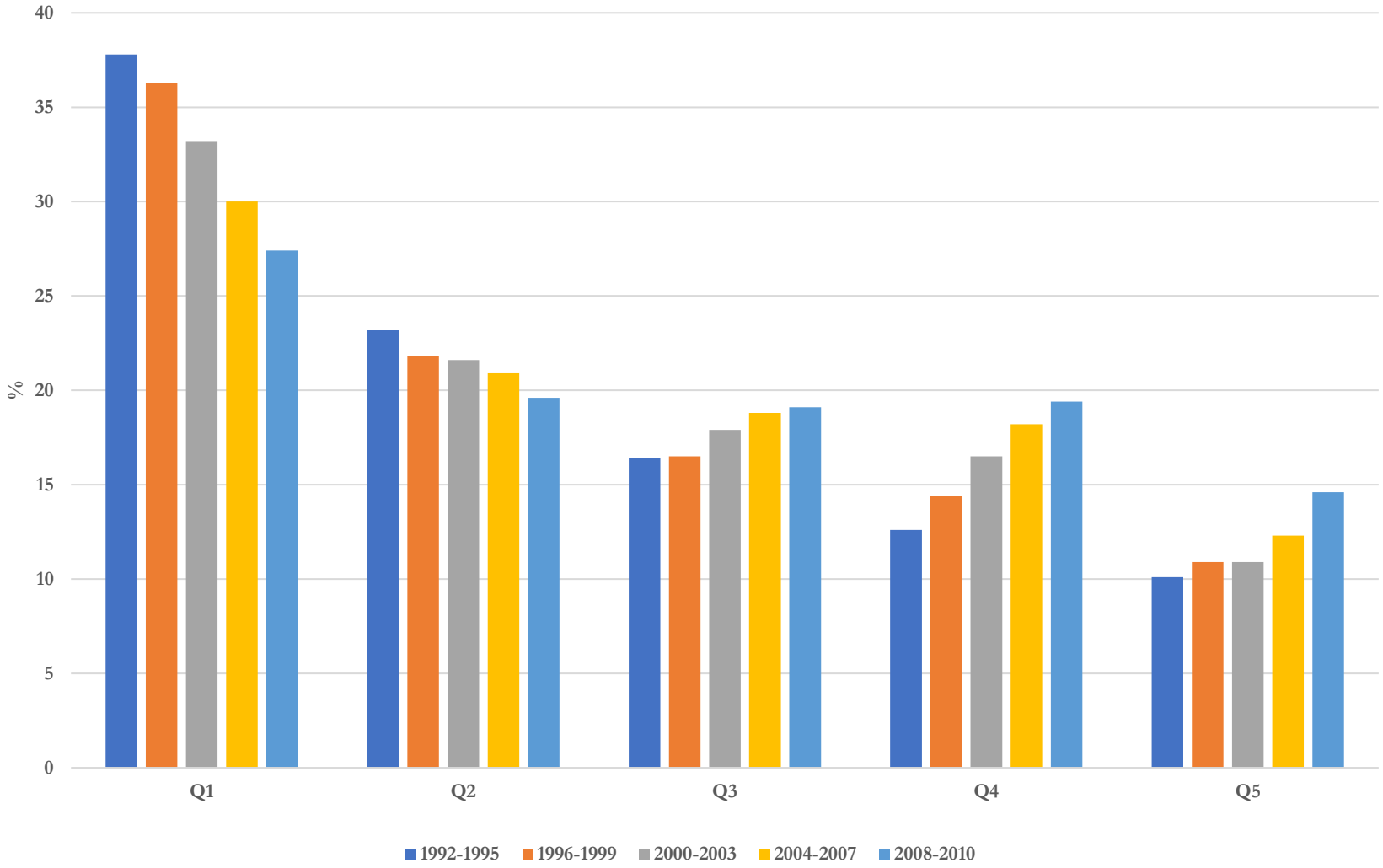


Table 4.2 Number of Events (n) and Rates of a Chronic Condition per 1,000 person-years for Immigrants and Long-term Ontario Residents, by Landing Cohort, during the Study Observation Period: 1995-2016

	Refugee		Family		Economic		Long-term Residents	
Landing Cohort	**n**	**Event Rate**	**n**	**Event Rate**	**n**	**Event Rate**	**n**	**Event Rate**
1992-1995	18300	30.6	46037	29.1	37115	26.6	109838	30.1
1996-1999	8711	29.1	24001	27.5	32787	21.8	68062	26.3
2000-2003	7595	28	21398	25.3	33615	20.6	60118	22.5
2004-2007	6361	23.4	12490	19.5	17975	20.2	32338	17.7
2008-2010	1527	19.4	4162	16.7	5914	16.8	8475	12.4

Table 4.3 Unadjusted Relative Risk (RR) and 95% Confidence Intervals (C.I) of developing a chronic condition per 1000 person-years follow-up, by landing cohort, for immigrant categories compared to long-term Ontario residents*, 1995—2016.

Landing Cohort	IMMGRANT CATEGORIES					
	Refugee		Family		Economic	
	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.
1992-1995	1.16	(1.13—1.19)	0.94	(0.93—0.95)	0.86	(0.85—0.87)
1996-1999	1.24	(1.20—1.28)	1.02	(1.00—1.04)	0.82	(0.81—0.83)
2000-2003	1.38	(1.33—1.43)	1.09	(1.07—1.11)	0.91	(0.89—0.93)
2004-2007	1.38	(1.33—1.43)	1.17	(1.14—1.20)	1.08	(1.06—1.10)
2008-2010	1.65	(1.50—1.80)	1.32	(1.25—1.39)	1.36	(1.31—1.41)

*The RR calculation compares the risk between each immigrant category to long-term residents who were matched to immigrants within each of those categories

Figure 4.3 Unadjusted Relative Risk of Developing a Chronic Condition by Landing Cohort between 1995-2016.

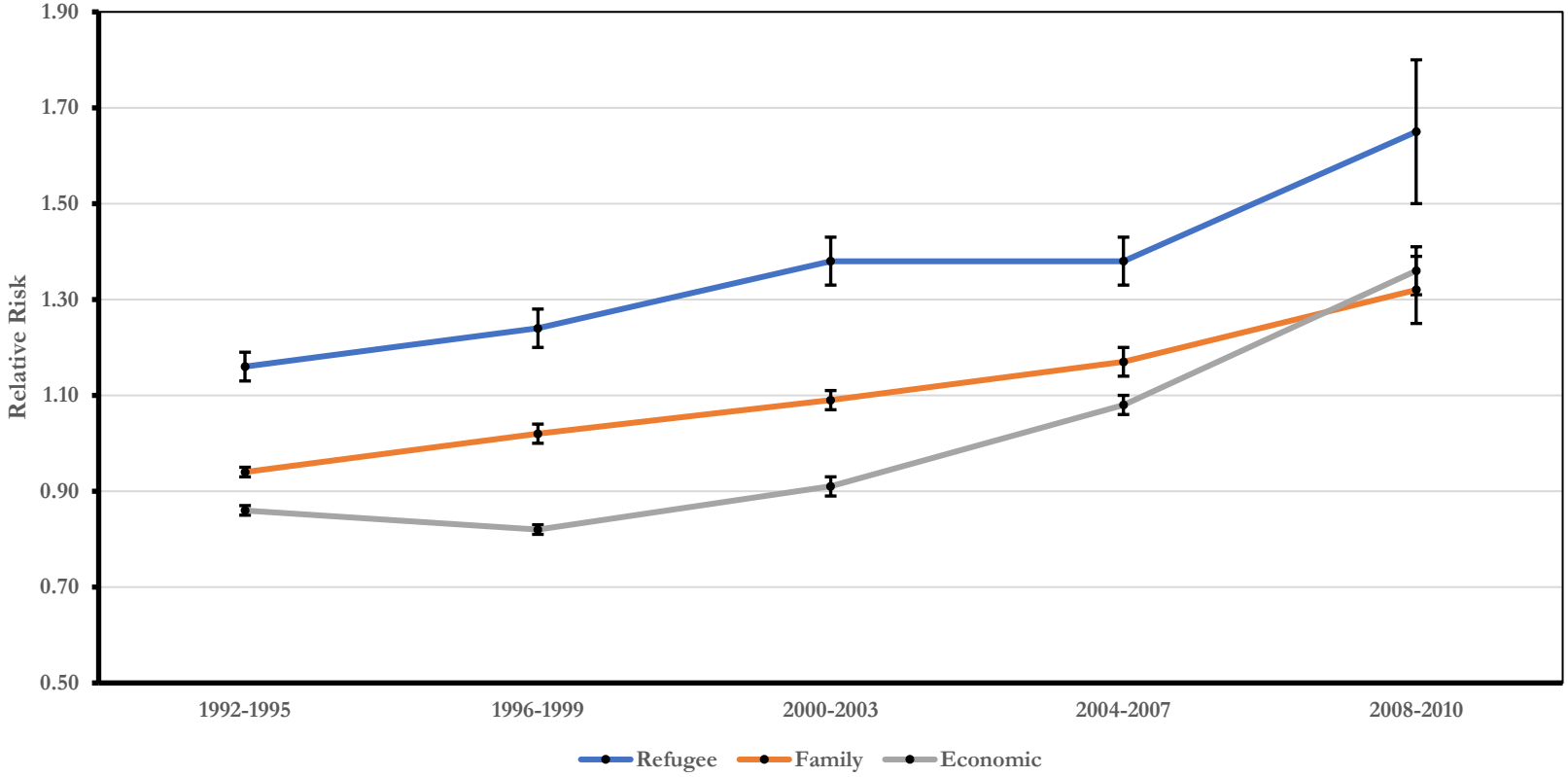


Table 4.4 Unadjusted time-specific relative risk (RR) and 95% confidence intervals (C.I) for developing a chronic condition by landing cohort, for each immigrant category compared to long-term residents per 1000 person-years follow-up

Immigrant Category	1996—1999		2000—2003		2004—2007		2008—2010		2011—2016	
Landing Cohort	**RR**	**95% C.I.**	**RR**	**95% C.I.**	**RR**	**95% C.I.**	**RR**	**95% C.I.**	**RR**	**95% C.I.**
REFUGEE										
1992—1995	1.16	(1.10—1.22)	1.14	(1.09—1.19)	1.19	(1.13—1.25)	1.16	(1.10—1.22)	1.17	(1.12—1.22)
1996—1999			1.25	(1.16—1.34)	1.27	(1.20—1.34)	1.20	(1.11—1.29)	1.22	(1.15—1.29)
2000—2003					1.39	(1.30 —1.48)	1.36	(1.27—1.45)	1.38	(1.31—1.45)
2004—2007							1.38	(1.28—1.48)	1.37	(1.30—1.44)
2008—2010									1.65	(1.52—1.78)
FAMILY										
1992—1995	0.90	(0.87—0.93)	0.88	(0.86—0.90)	0.95	(0.93—0.97)	1.00	(0.97—1.03)	1.01	(0.98—1.04)
1996—1999			1.03	(0.99—1.07)	1.05	(1.02—1.08)	0.99	(0.95—1.03)	1.01	(0.97—1.05)
2000—2003					1.14	(1.10—1.18)	1.04	(1.00—1.08)	1.10	(1.07—1.13)
2004—2007							1.18	(1.12—1.24)	1.17	(1.13—1.21)
2008—2010									1.32	(1.26—1.38)
ECONOMIC										
1992—1995	0.90	(0.87—0.93)	0.83	(0.80—0.86)	0.86	(0.83 —0.89)	0.88	(0.85—0.91)	0.88	(0.86—0.90)
1996—1999			0.99	(0.96—1.02)	0.90	(0.88—0.92)	0.73	(0.71—0.75)	0.72	(0.70—0.74)
2000—2003					1.07	(1.04—1.10)	0.91	(0.89—0.94)	0.83	(0.81—0.85)
2004—2007							1.13	(1.08—1.18)	1.06	(1.04—1.08)
2008—2010									1.35	(1.29—1.41)

*The RR calculation compares the risk between each immigrant category to long-term residents who were matched to immigrants within each of those categories

Figure 4.4 Unadjusted Time-specified Relative Risk for Developing a Chronic Condition, by Landing Cohort, for Refugees compared to Long-term Residents

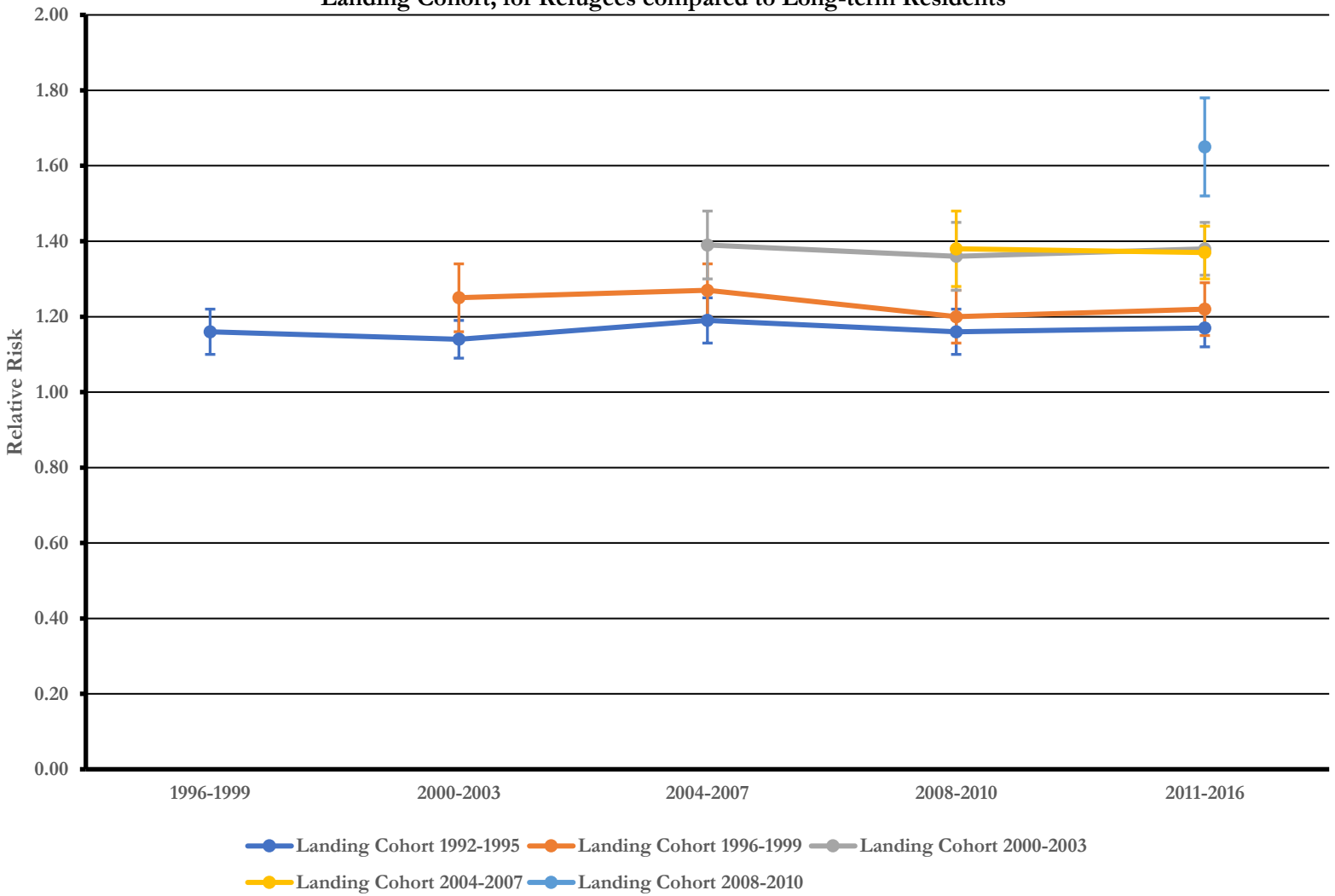


Figure 4.5 Unadjusted, Time-specified Relative Risk for Developing a Chronic Condition, by Landing Cohort, for Family Immigrants compared to Long-term Residents.

Figure 4.6 Unadjusted, Time-specified Relative Risk for Developing a Chronic Condition, by Landing Cohort, for Economic Immigrants compared to Long-term Residents.

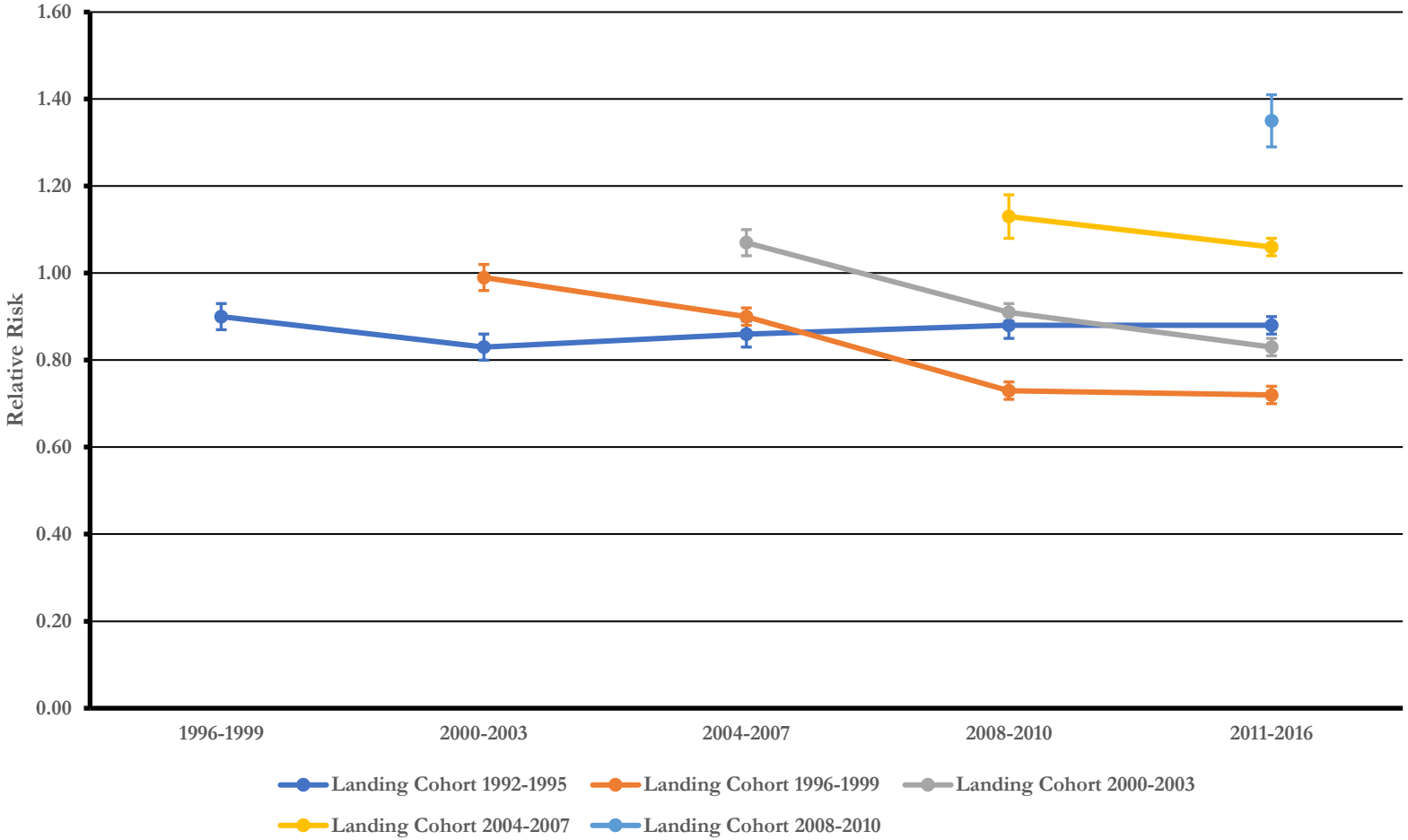


Table 4.5 Unadjusted Hazard Ratios (HR) and 95% Confidence Intervals (C.I) of a chronic condition event for immigrant categories, by landing cohort, compared to long-term residents, stratified by age categories.

Age	IMMIGRANT CATEGORY					
	Refugees N=151, 698		Family Class N=417, 422		Economic Class N= 586,560	
Year	Hazard Ratio	95% C.I.	Hazard Ratio	95% C.I.	Hazard Ratio	95% C.I.
18-29 years						
1992-1995	1.17	(1.11—1.23)	1.11	(1.08—1.14)	0.87	(0.84—0.90)
1996-1999	1.23	(1.13—1.33)	1.21	(1.16—1.26)	0.81	(0.77—0.85)
2000-2003	1.35	(1.23—1.47)	1.28	(1.22—1.34)	0.90	(0.85—0.95)
2004-2007	1.34	(1.19—1.49)	1.34	(1.26—1.42)	1.09	(1.00—1.18)
2008-2010	1.42	(1.13—1.71)	1.43	(1.26—1.60)	1.26	(1.07—1.45)
30-44 years						
1992-1995	1.18	(1.15—1.21)	1.08	(1.05—1.11)	0.92	(0.90—0.94)
1996-1999	1.27	(1.22—1.32)	1.13	(1.09—1.17)	0.83	(0.82—0.84)
2000-2003	1.41	(1.34—1.48)	1.12	(1.08—1.16)	0.92	(0.89—0.95)
2004-2007	1.37	(1.29—1.45)	1.09	(1.04—1.14)	1.09	(1.06—1.12)
2008-2010	1.65	(1.46—1.84)	1.20	(1.10—1.30)	1.38	(1.31—1.45)
45+ years						
1992-1995	1.12	(1.06—1.18)	0.73	(0.71—0.75)	0.73	(0.71—0.75)
1996-1999	1.21	(1.13—1.29)	0.84	(0.81—0.87)	0.80	(0.78—0.82)
2000-2003	1.41	(1.32—1.50)	1.01	(0.98—1.04)	0.91	(0.88—0.94)
2004-2007	1.45	(1.35—1.55)	1.20	(1.15—1.25)	1.06	(1.03—1.09)
2008-2010	1.77	(1.56—1.98)	1.42	(1.33—1.51)	1.35	(1.27—1.43)

*The Population N size of long-term residents is equal to the N displayed for each immigrant category.

Figure 4.7 Unadjusted Hazard Ratios for Refugees, compared to Long-term Residents, by Landing Cohort and Age Categories.

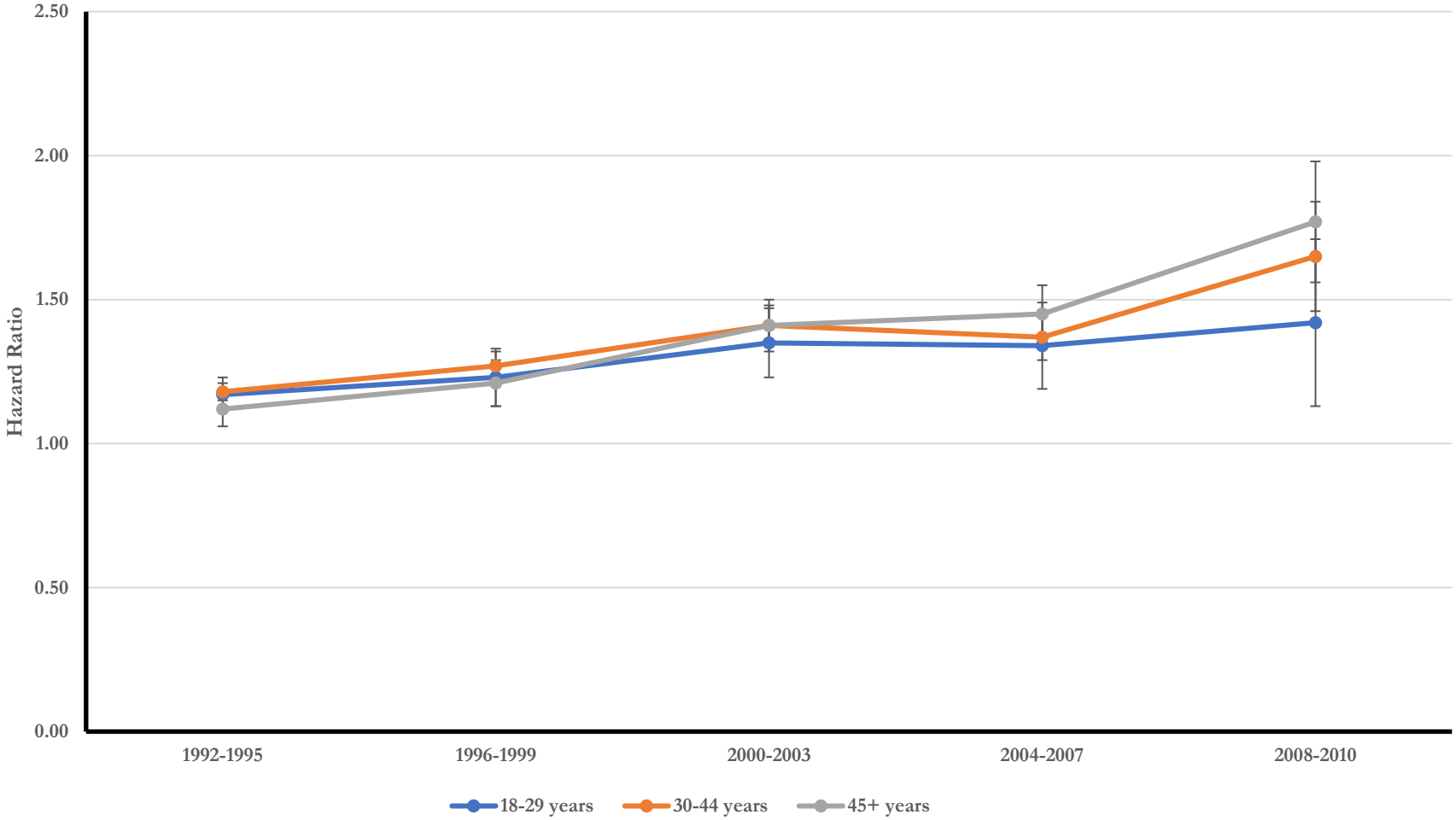


Figure 4.8 Unadjusted Hazard Ratios for Family Immigrants, compared to Long-term Residents by Landing Cohort and Age Categories.

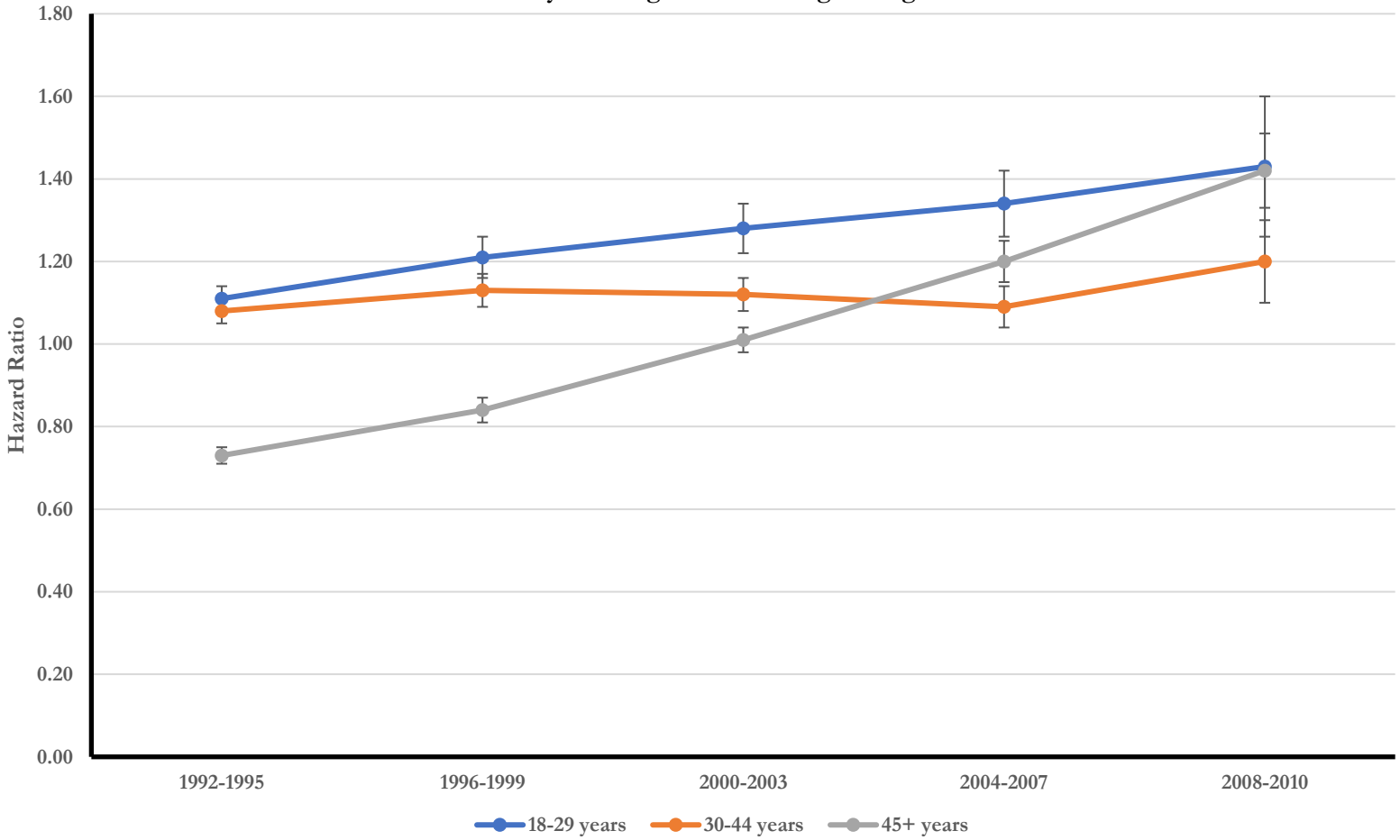


Figure 4.9 Unadjusted Hazard Ratios for Economic Immigrants, compared to Long-term Residents, by Landing Cohort and Age Categories.

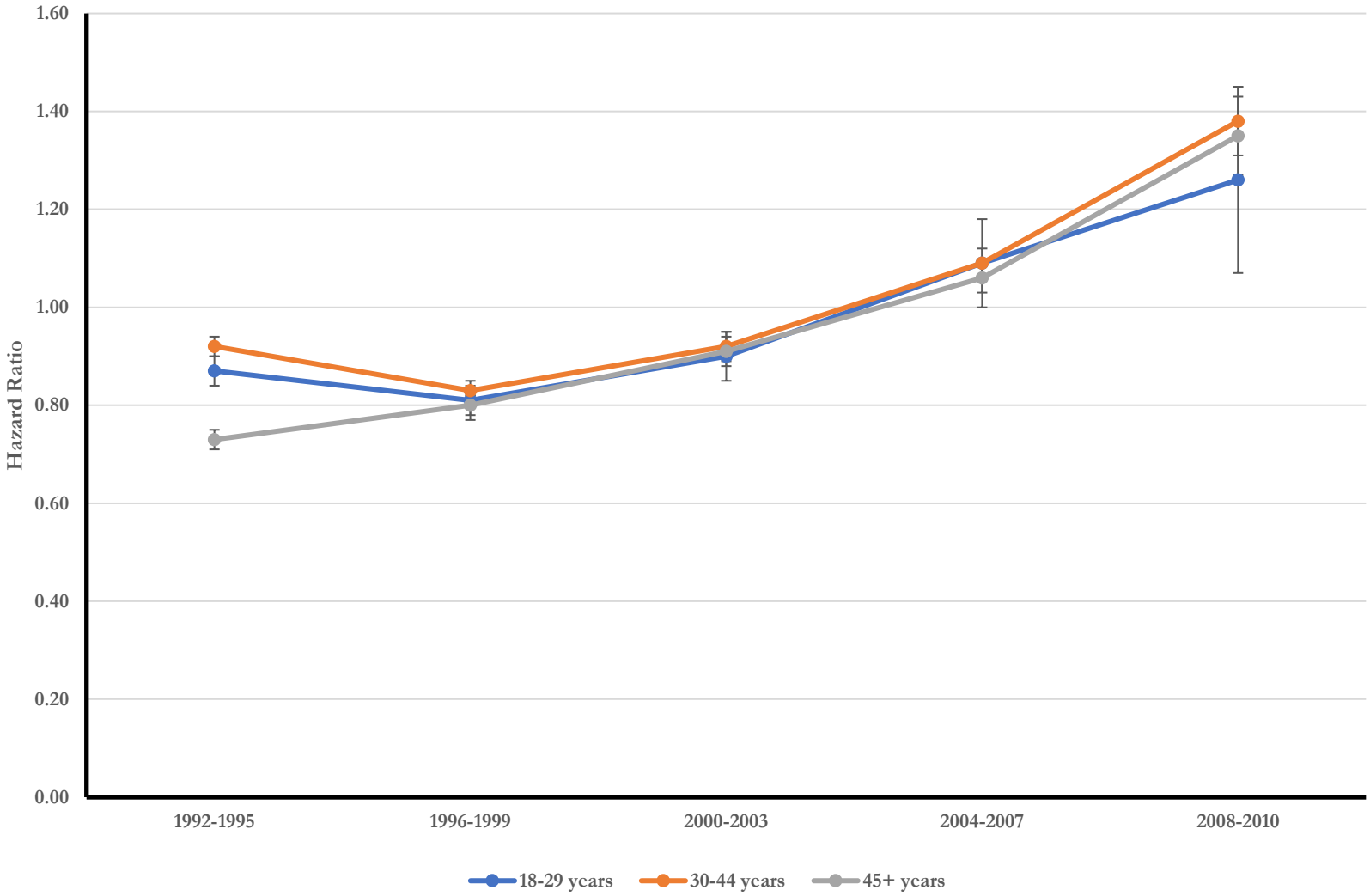


Table 4.6 Unadjusted Hazard Ratios (HR) and 95% Confidence Intervals (C.I) of a chronic condition event for immigrant categories, by landing cohort, compared to long-term residents, stratified by world regions of origin.

World Region of Origin	Immigrant Categories					
	Refugees N=151,053		Family Class N=416,317		Economic Class N=585,539	
Landing Period	Hazard Ratio	95% C.I.	Hazard Ratio	95% C.I.	Hazard Ratio	95% C.I.
Caribbean						
1992—1995	1.13	(0.96—1.30)	1.22	(1.18—1.26)	1.34	(1.28—1.39)
1996—1999	1.19	(1.02—1.36)	1.30	(1.26—1.34)	1.21	(1.16—1.27)
2000—2003	1.31	(1.12—1.50)	1.40	(1.35—1.45)	1.31	(1.25—1.37)
2004—2007	1.39	(1.19—1.59)	1.55	(1.49—1.61)	1.55	(1.48—1.62)
2008—2010	1.65	(1.38—1.92)	1.75	(1.66—1.84)	1.72	(1.55—1.89)
East Asia & the Pacific						
1992—1995	0.92	(0.87—0.97)	0.75	(0.73—0.77)	0.78	(0.77—0.79)
1996—1999	0.96	(0.90—1.02)	0.80	(0.78—0.82)	0.70	(0.69—0.72)
2000—2003	1.06	(1.00—1.12)	0.86	(0.84—0.88)	0.76	(0.75—0.77)
2004—2007	1.13	(1.06—1.20)	0.95	(0.92—0.98)	0.90	(0.88—0.92)
2008—2010	1.33	(1.20—1.46)	1.08	(1.03—1.13)	1.16	(1.11—1.21)
Eastern Europe & Central Asia						
1992—1995	0.93	(0.90—0.96)	0.78	(0.77—0.79)	0.84	(0.82—0.85)
1996—1999	0.97	(0.93—1.01)	0.83	(0.81—0.85)	0.76	(0.74—0.77)
2000—2003	1.08	(1.03—1.13)	0.89	(0.86—0.92)	0.82	(0.80—0.84)
2004—2007	1.14	(1.08—1.20)	0.99	(0.95—1.03)	0.97	(0.95—0.99)
2008—2010	1.35	(1.23—1.47)	1.12	(1.06—1.18	1.25	(1.20—1.30)
Latin America						
1992—1995	0.88	(0.83—0.93)	1.01	(0.98—1.04)	0.82	0.79—0.85)
1996—1999	0.92	(0.86—0.98)	1.07	(1.03—1.11)	0.75	(0.72—0.78)
2000—2003	1.01	(0.95—1.07)	1.15	(1.10—1.20)	0.81	(0.77—0.84)
2004—2007	1.07	(1.00—1.14)	1.28	(1.23—1.33)	0.95	(0.90—1.00)
2008—2010	1.27	(1.15—1.39)	1.44	(1.36—1.52)	1.23	(1.16—1.30)
North Africa & the Middle East						
1992—1995	1.06	(1.01—1.11)	0.83	(0.80—0.86)	0.79	(0.77—0.81)
1996—1999	1.11	(1.06—1.16)	0.88	(0.84—0.92)	0.72	(0.70—0.74)
2000—2003	1.23	(1.17—1.29)	0.95	(0.91—0.99)	0.77	(0.75—0.79)

Table 4.6 Unadjusted Hazard Ratios (HR) and 95% Confidence Intervals (C.I) of a chronic condition event for immigrant categories, by landing cohort, compared to long-term residents, stratified by world regions of origin.

World Region of Origin	Immigrant Categories					
	Refugees N=151,053		Family Class N=416,317		Economic Class N=585,539	
Landing Period	Hazard Ratio	95% C.I.	Hazard Ratio	95% C.I.	Hazard Ratio	95% C.I.
2004—2007	1.30	(1.23—1.37)	1.05	(1.00—1.10)	0.92	(0.89—0.95)
2008—2010	1.54	(1.40—1.68)	1.18	(1.12—1.24)	1.18	(1.13—1.23)
South Asia						
1992—1995	1.71	(1.66—1.76)	1.24	(1.22—1.26)	1.26	(1.24—1.28)
1996—1999	1.79	(1.72—1.86)	1.31	(1.28—1.34)	1.14	(1.12—1.16)
2000—2003	1.98	(1.90—2.06)	1.41	(1.38—1.44)	1.23	(1.21—1.25)
2004—2007	2.10	(2.01—2.19)	1.56	(1.51—1.61)	1.46	(1.43—1.49)
2008—2010	2.48	(2.26—2.70)	1.77	(1.69—1.85)	1.88	(1.81—1.95)
Sub—Saharan Africa						
1992—1995	1.20	(1.15—1.25)	1.08	(1.03—1.13)	0.99	(0.94—1.04)
1996—1999	1.25	(1.19—1.31)	1.15	(1.10—1.20)	0.90	(0.86—0.94)
2000—2003	1.39	(1.32—1.46)	1.24	(1.18—1.30)	0.97	(0.92—1.02)
2004—2007	1.47	(1.40—1.54)	1.37	(1.30—1.44)	1.15	(1.09—1.21)
2008—2010	1.74	(1.58—1.90)	1.54	(1.48—1.60)	1.48	(1.39—1.57)
Western Europe & US						
1992—1995	1.08	(0.82—1.34)	0.64	(0.61—0.67)	0.60	(0.57—0.63)
1996—1999	1.13	(0.85—1.41)	0.68	(0.65—0.71)	0.54	(0.52—0.56)
2000—2003	1.25	(0.95—1.55)	0.74	(0.71—0.77)	0.58	(0.56—0.60)
2004—2007	1.33	(1.01—1.65)	0.82	(0.78—0.86)	0.69	(0.66—0.72)
2008—2010	1.57	(1.16—1.98)	0.92	(0.87—0.97)	0.88	(0.82—0.94)

*The Population N size of long-term residents is equal to the N displayed for each immigrant category.

Figure 4.10 Unadjusted Hazard Ratios for Refugees, compared to Long-term Residents, by Landing Cohort and World Regions of Origin.

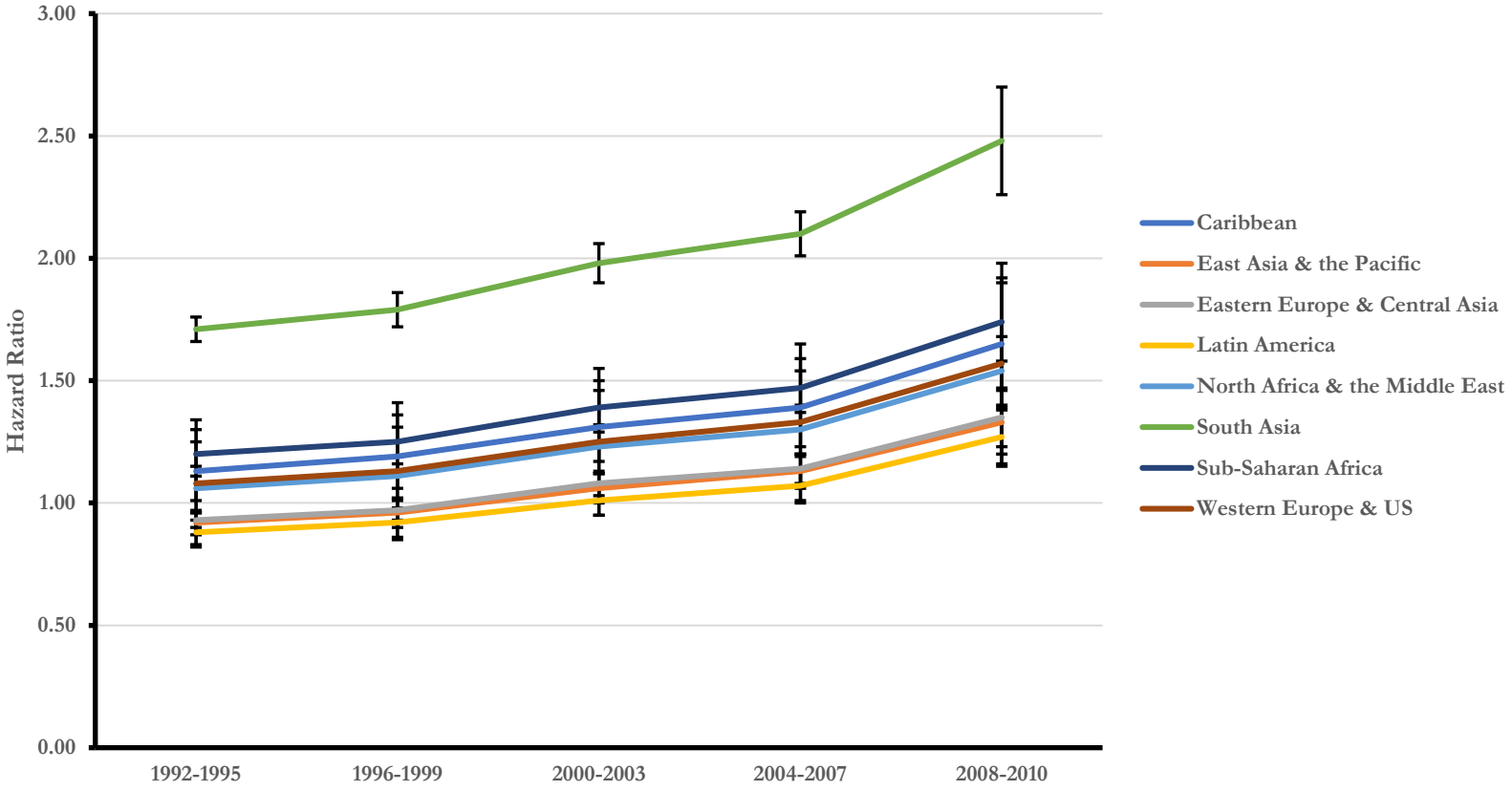


Figure 4.11 Unadjusted Hazard Ratios for Family Immigrants, compared to Long-term Residents, by Landing Cohort and World Regions of Origin.

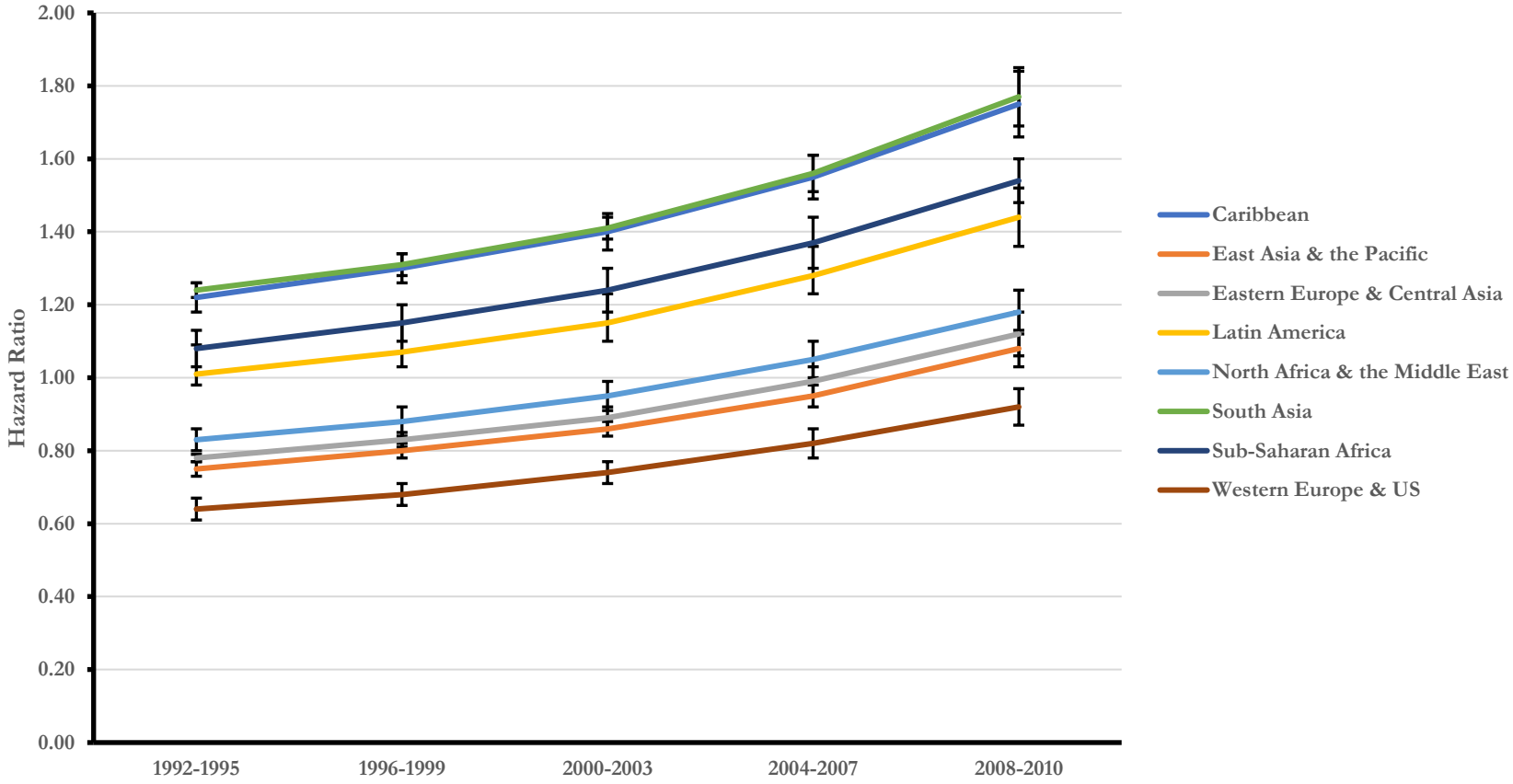


Figure 4.12 Unadjusted Hazard Ratios for Economic Immigrants, compared to Long-term Residents, by Landing Cohort and World Regions of Origin.

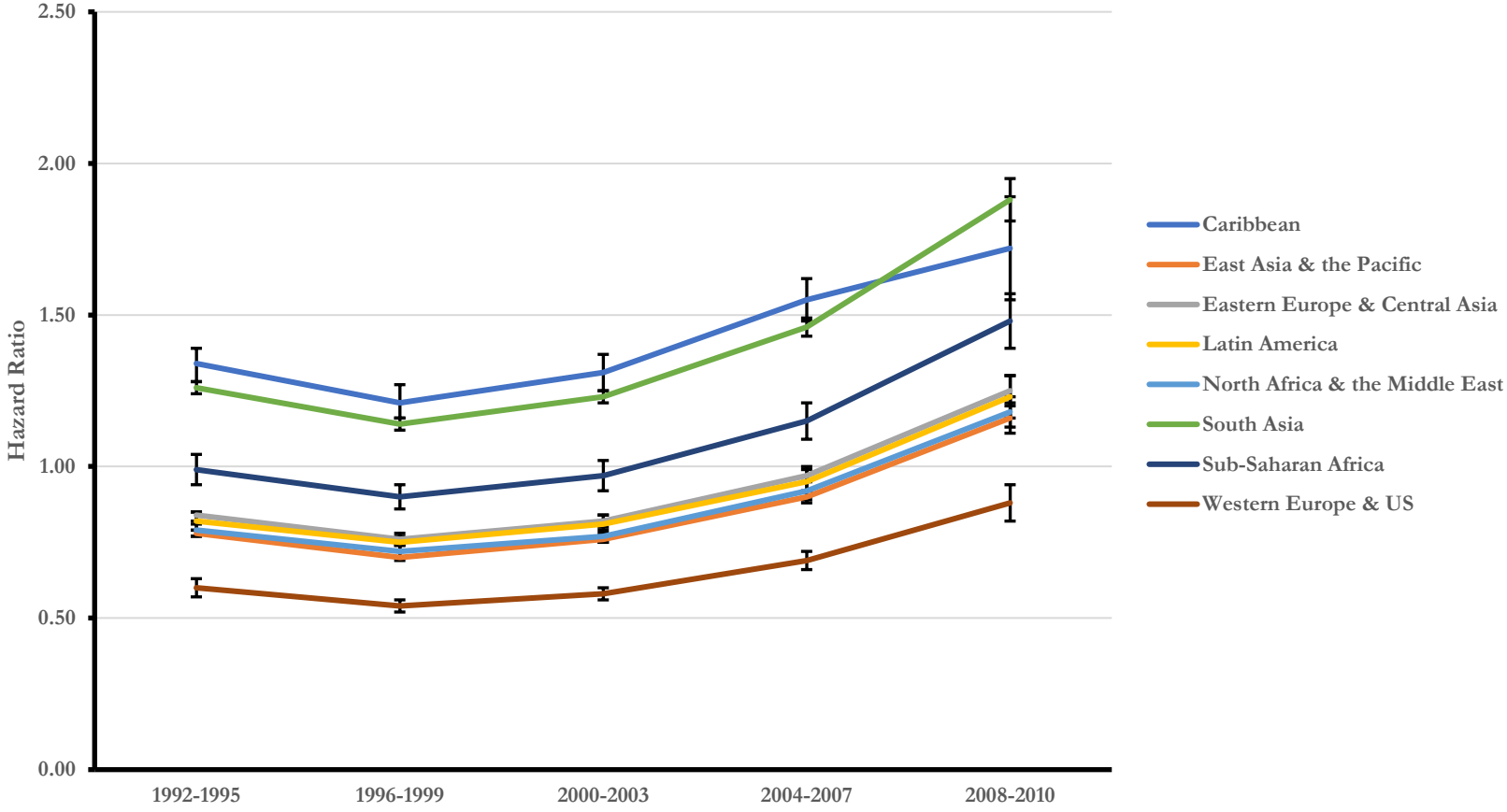


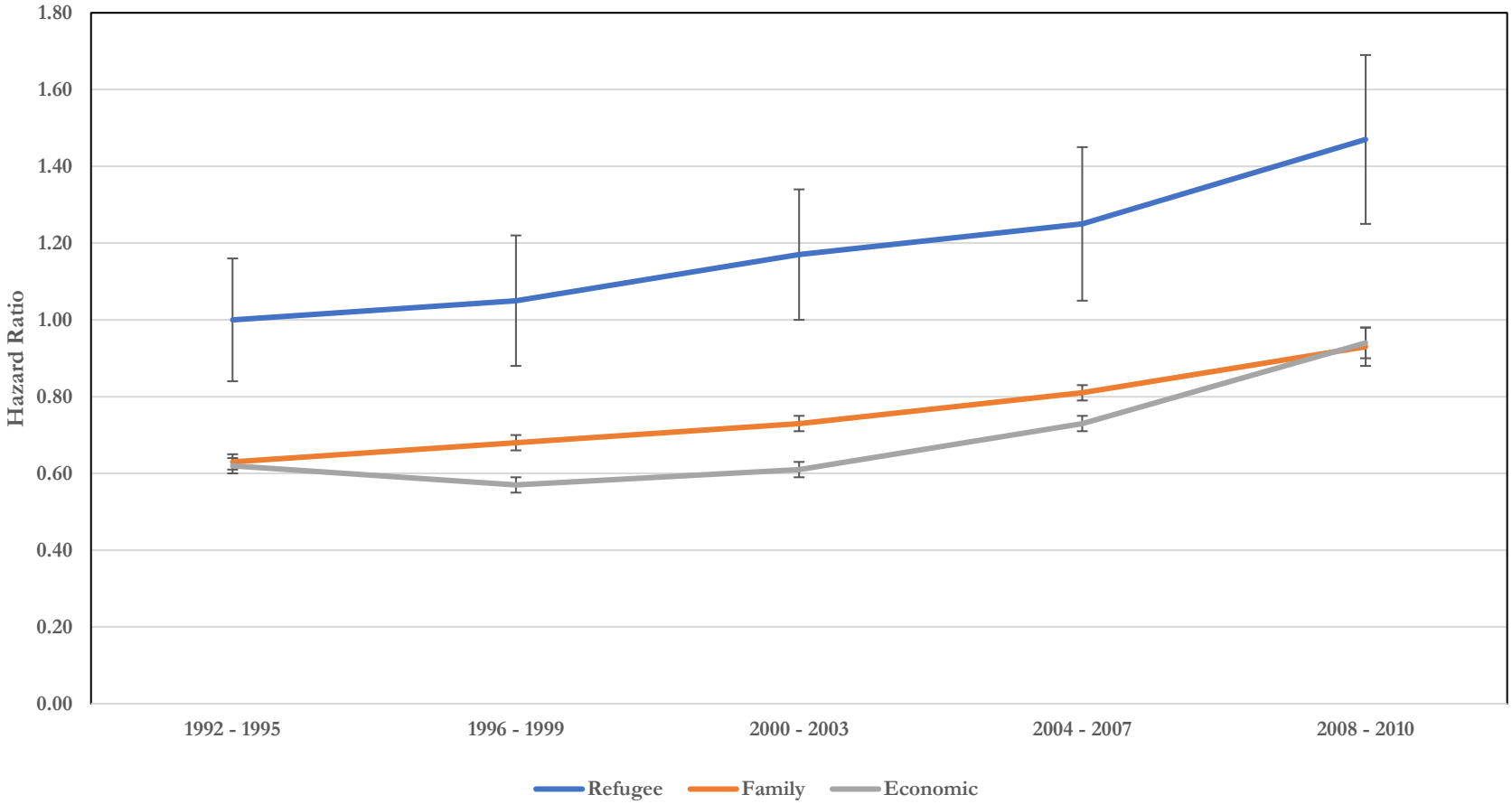
Table 4.7 Adjusted Hazard Ratios (HR) and 95% Confidence Intervals (C.I): Multivariate Cox Proportional Hazard model for developing a chronic condition, for immigrant categories compared to long-term residents by landing cohort.

	Immigrant Category					
	REFUGEE N=151,349		FAMILY N=416, 826		ECONOMIC N=586, 023	
	HR	95% C.I.	HR	95% C.I.	HR	95% C.I.
Immigrant*Landing Cohort Interaction						
1992—1995	1.00	(0.84—1.16)	0.63	(0.61—0.65)	0.62	(0.60—0.64)
1996—1999	1.05	(0.88—1.22)	0.68	(0.66—0.70)	0.57	(0.55—0.59)
2000—2003	1.17	(1.00—1.34)	0.73	(0.71—0.75)	0.61	(0.59—0.63)
2004—2007	1.25	(1.05—1.45)	0.81	(0.79—0.83)	0.73	(0.71—0.75)
2008—2010	1.47	(1.25—1.69)	0.93	(0.88—0.98)	0.94	(0.90—0.98)
Age Category						
18-29 (reference)	—	—	—	—	—	—
30-44	2.05	(2.01—2.09)	1.84	(1.82—1.86)	2.07	(2.04—2.10)
45+	4.57	(4.47—4.67)	5.24	(5.18—5.30)	4.07	(4.01—4.13)
Sex						
Female	0.96	(0.94—0.97)	0.91	(0.90—0.92)	0.92	(0.91—0.93)
Male (reference)	—	—	—	—	—	—
Income Quintile						
Q1 (lowest income)	1.22	(1.19—1.26)	1.27	(1.25—1.29)	1.27	(1.25—1.28)
Q2	1.19	(1.16—1.23)	1.20	(1.18—1.22)	1.21	(1.19—1.22)
Q3	1.13	(1.10—1.16)	1.15	(1.14—1.17)	1.16	(1.15—1.18)
Q4	1.09	(1.05—1.12)	1.09	(1.07—1.11)	1.11	(1.10—1.13)
Q5 (reference)	—	—	—	—	—	—
World Region of Origin						
Caribbean	2.07	(1.99—2.15)	1.73	(1.68—1.79)	1.39	(1.35—1.42)
East Asia & the Pacific	1.08	(1.03—1.14)	0.89	(0.86—0.93)	0.86	(0.82—0.90)
Eastern Europe & Central Asia	1.29	(1.25—1.33)	1.23	(1.19—1.27)	0.90	(0.78—1.05)
Latin America	1.08	(1.03—1.14)	1.25	(1.16—1.28)	0.84	(0.72—0.98)
North Africa & the Middle East	1.28	(1.24—1.32)	1.23	(1.19—1.27)	1.01	(0.87—1.17)
South Asia	1.93	(1.87—1.98)	1.83	(1.78—1.88)	1.57	(1.36—1.82)
Sub-Saharan Africa	1.61	(1.55—1.68)	1.54	(1.48—1.60)	1.12	(0.97—1.30)
ON-resident (reference)	—	—	—	—	—	—

* Adjusted HR of immigrant status*landing cohort interaction term obtained from the stratified multivariate models.
* The immigrant*landing cohort interaction term compared immigrants to long-term Ontario residents. The reference category is the long-term Ontario residents when comparing the effect immigration within each landing cohort.

*The Population N size of long-term residents is equal to the N displayed for each immigrant category.

Figure 4.13 Adjusted Hazard Ratios for Developing a Chronic Condition for Immigrant Categories, compared to Long-term Residents, by Landing Cohort.



Adjusted by age, sex, neighborhood level income quintiles, world regions of origin and an interaction term between

4.5 DISCUSSION

4.5.1 Main Findings

In this study we examined the impact of cohorts on chronic health outcomes among different immigrant populations in Canada. We found that the risk of developing a chronic condition increased among immigrants in more recent landing cohorts. A period effect was confirmed in our relative risk analysis for each landing cohort, over time, across all immigrant categories. This period effect was also apparent after observing an increased risk in more recent cohorts across all age groups and world regions of origin.

Refugees had the highest risk of developing a chronic condition, compared to long-term residents of Ontario, across all landing cohorts. More recent refugees had the highest risk compared to those who landed in earlier cohorts. Among family and economic class immigrants, the risk of developing a chronic condition remained lower than long-term residents, for all landing cohorts, but increased among more recent cohorts, when compared to those who landed in earlier landing cohorts.

The year of landing in a host country is an important consideration in study design and methodological analyses in migration studies (Ro, Geronimus, Bound, Griffith, & Gee, 2015). Differences in the composition of immigrants at the year or time-period of landing, as well as health trends unique to individual cohorts from the time of their arrival, could lead to different settlement experiences and subsequent health outcomes, compared to those who arrived at a different point in time. These differences can be attributed to changes in immigration policy (as conceptualized in the CSDH framework), demographics (e.g. composition across age groups and world regions of origin) and changing global rates and patterns of disease and risk factors (Lauderdale, 2007; Ro et al., 2015).

Our study confirms existing research on the relationship between immigrant cohorts and health outcomes. Guintella and Stella (2017) examined cohort differences in obesity outcomes and

reported that more recent immigrants had higher baseline rates of obesity upon landing and had a higher rate of unhealthy weight assimilation compared to immigrants who arrived in earlier cohorts. In several US studies, immigrants who arrived in earlier cohorts reported better reported health than cohorts who immigrated to the US in more recent years (Antecol & Bedard, 2006; Hamilton & Hummer, 2011). In a Canadian study, Creatore and colleagues (2013) considered age-period-cohort effects in their analyses and reported significant cohort effects with respect to diabetes outcomes using population-based administrative health data. More recent immigrants had a higher risk of having a diabetes diagnosis than immigrants who arrived in earlier cohorts, after controlling for age, sex, and other socio-demographic characteristics (Creatore, 2013).

Other studies have reported that more recent immigrant cohorts had better health outcomes than those who arrived in earlier cohorts. Antecol and Bedard (2015) studied the impact of cohorts among immigrants using data from the National Health Interview Survey (1989-2011) to examine self-reported health measures of poor health, weight, and the existence of at least one activity limitation. More recent immigrants reported better health than those who came in earlier cohorts across most racial/ethnic groups (Antecol & Bedard, 2015).

Ro and colleagues (2015) investigated cohort and duration patterns among Asian immigrants in the US, using multiple waves of the National Health Interview Surveys, to examine obesity and self-rated health outcomes. Using five-year intervals for an immigrant's year of arrival, more recent immigrants reported better health compared to older cohorts. However, over time, older cohorts showed improved self-rated health with longer duration in the US (Ro, Geronimus, Bound, Griffith, & Gee, 2015). In Europe, a study pooled four cross-sections of the Survey of Health, Aging and Retirement using data from 19 immigrant host countries in Europe and looked at immigrant health trajectories to compare recent and longer-term immigrants. More recent immigrants had better self-reported health compared to longer-term immigrants. The study reported

a significant deterioration of health status with years spent in the host country (Constant, 2017; Constant, García-Muñoz, Neuman, & Neuman, 2018). Similar findings were also reported in an analysis representing 22 countries that are part of the Organization for Economic Cooperation and Development from the Programme for the International Assessment of Adult Competencies dataset (Constant et al., 2018).

However, all these studies were cross-sectional, did not distinguish between immigrant category, did not have data such as country or world region of origin, and examined self-reported health data that is different from the outcome measures were used in our study.

The elevated risk of chronic conditions among more recent cohorts in our studies can be examined by considering immigration policy changes over the years, as well as the impact of social determinants of health among recent immigrants, as conceptualized in our application of the CSDH model across different immigrant populations.

Immigration policy, labor market structures, educational institutions and welfare systems are major factors associated with the characteristics of incoming immigrants (Kaushal & Lu, 2015; Smith & Reitz, 2006). An examination of immigration policies is critical to better understanding changes in the immigrant population, since such policies can influence the way in which immigrants and refugees are selected and the way the government responses to their needs (Rouhani, 2011).

Over the years, Canada has undergone several immigration policy changes. In 2002, the government of Canada enacted the Immigrant and Refugee Protection Act (IRPA) impacting the composition of future refugees entering Canada. This policy change shifted federal government priorities from ensuring successful integration of refugees to a greater focus on their protection and safety. Medical screening protocols have traditionally been in place to ensure that the healthiest and most adaptable immigrants and refugees are accepted into Canada (Mayhew et al., 2015; Rouhani, 2011). Following the IRPA, the government modified the medical screening criteria and has been

accepting refugees that are more disadvantaged and less likely to adapt to Canadian society than previous refugees (Beiser, 2005; Gushulak, 2010; Rouhani, 2011). As a result, refugees that have entered Canada after 2002, have a greater risk of experiencing poor health outcomes than previous cohorts (Rouhani, 2011; Mayhew et al., 2015). This policy change may contextualize why refugees in more recent landing cohorts had a higher risk of developing a chronic condition than previous cohorts prior to 2002.

Other important policy considerations include changes to immigration selection based on educational attainment and language proficiency, using an explicit point system in Canada for non-refugee immigrants (Kaushal & Lu, 2015) all of which impact both the structural determinants of health and the material circumstances that affect the social positioning of an immigrant post-settlement to Canada. For example, in 1992, the Canadian federal government allocated 12 and 15 points (out of 100) to high education and French or English proficiency, respectively. By 2006, prospective immigrants received 20 to 25 points depending on their university-level degree attainment and 24 points to their language proficiency (Kaushal & Lu, 2015). The increase in the Canadian immigration point system has led to an increase in the number of immigrants with higher education and greater language proficiency (Kaushal & Lu, 2015), a trend that was observed in our data.

A study examined immigration selection to Canada and the US between 1990 to 2006, with a focus on educational attainment, language proficiency and entry-level wages (Kaushal & Lu, 2015). While there was an increase in the level of education attainment and language proficiency, more recent immigrants to Canada experienced a greater wage disadvantage compared to Canadian natives. This earning disadvantage worsened over time despite their increase in human capital (Lu, Kaushal, Denier, & Wang, 2017). The authors suggested that while the point system has effectively screened in immigrants on education and language proficiency, it has failed to capture characteristics

associated with skills and earning, potentially as a result of lower returns to education or a mismatch between their educational levels and jobs availability for Canadian immigrants (Kaushal & Lu, 2015; Lu et al., 2017). These findings are consistent with previous research reporting that the education advantage of immigrants to Canada disappeared shortly after immigration, once immigrants from the same source country were compared to one another in the US and Canada (George J. Borjas, 1991; Kaushal & Lu, 2015).Moreover, prior research on the economic assimilation of immigrants reported that more recent immigrants had lower earnings upon entry and less economic assimilation than earlier cohorts (G J Borjas, 1995; George J. Borjas, 2016; Giuntella & Stella, 2017). Such disadvantages can lead to greater economic disparities, limited ability to integrate and settle in the host country, and heightened stress, all of which increase the risk of adverse health outcomes post-settlement.

Research on the impact of food security on the health of immigrants has emerged in recent literature, since food insecurity contributes to poor diet, higher rates of obesity, self-reported poor health, depression, type 2 diabetes, and heart disease (Tarraf, Sanou, & Giroux, 2017). A recent literature review reported that food insecurity disproportionally affects recent immigrants. Unemployment and low income have been associated with greater food insecurity among recent immigrants in the first years following immigration. In Canada, data from 2011 to 2012 found that food insecurity was higher among more recent immigrants compared with non-recent immigrants and the Canadian-born population (Tarraf, Sanou, & Giroux, 2017). Immigrants who have been in Canada for less than 1 year experienced the highest rates of food insecurity compared with less recent immigrants (Tarasuk & Vogt, 2009; Tarraf et al., 2017; Vahabi, Damba, Rocha, & Montoya, 2011). Limited language proficiency, higher use of food banks and social assistance are indicators of food insecurity, as a result of minimum wages, and lack of affordable housing and childcare among recent immigrants in Canada (Tarraf et al., 2017).

A report on health inequalities in Canada examined health outcome and social determinants of health indicators in the Canadian population (Public Health Agency of Canada, 2018). Using data from the National Household Survey, recent immigrants to Canada had two times higher prevalence of core housing need compared to those born in Canada, with an even higher rate among recent immigrants of visible minority compared to Canadian-born individuals not classified as a visible minority (Public Health Agency of Canada, 2018). The prevalence of working poverty was also 2.0 and 1.5 times higher among recent immigrants living in Canada for less than 10 years and 10 or more years respectively, compared to Canadian-born individuals (Public Health Agency of Canada, 2018).

These findings highlight the impact of social determinants of health, particularly the material circumstances that affect the social positioning of an immigrant in Canada and may further contextualize the elevated risk of chronic health outcomes observed among more recent immigrant cohorts in our study.

4.5.2 Strengths and limitations of the study

We had a unique opportunity to study a diverse immigrant population, migrating at different points in time, from different world regions of origin, across diverse sociodemographic profiles. To our knowledge, no other studies in Canada have extensively examined the impact of immigrant cohorts in health outcomes. This study addressed existing knowledge gaps and previous methodological limitations by utilizing population-based administrative health and immigrant data over a 20-year observational period.

Previous studies have used self-reported, cross-sectional data, or lacked information such as exact year of landing, region of origin or immigrant category (Antecol & Bedard, 2015; Ro et al., 2015). Our study overcame these methodological challenges by using a longitudinal study design, and a large sample size to conduct stratified analyses representing immigrants across major

immigrant categories and world regions of origin. Furthermore, we followed a healthy cohort of immigrants, with no disease diagnosis three years after their landing, to examine the impact of cohorts and the risk of developing a chronic condition in Canada. This approach enabled us to ascertain differences in the risk of chronic condition outcomes, among different immigrant cohorts after arrival, by excluding immigrants who came to Canada with an existing chronic condition prior to settlement.

In this study, we were unable to examine all chronic conditions as well as the impact of these conditions. Our findings may underestimate the immigrant populations' risk of developing a chronic condition since most chronic condition algorithms used in the ICES-derived disease cohorts favor specificity over sensitivity (Appendix E), thereby resulting in some under-estimation. Mental health conditions were not captured in our disease cohorts and are an important factor to consider when studying migrant health (Hollander et al., 2012; Hollander, Bruce, Burström, & Ekblad, 2013; Reed & Barbosa, 2017).

Our data also did not include several social determinants of health, such as lifestyle and behavioural variables, factors which can impact the acculturative process of immigrant settlement, and particularly how changes in lifestyle and behaviour can impact health outcomes for immigrants over the lifespan. Our study was also limited to migrant characteristics and socio-economic factors (i.e., neighborhood-level income profiles) available at their time of landing or 3-years following an immigrant's arrival to Canada, respectively. Factors such as income, are important social determinants of health that can impact an immigrant's ability to successfully integrate into Canadian society and ultimately how they experience health outcomes, over time.

4.5.3 Study Implications and Future Directions for Policy and Program Planning

Findings from this study demonstrate how immigrant cohorts can reveal differences in the way in which immigrants integrate and experience health outcomes in Canada. This study highlights

the need to consider cohorts as a broader context of immigration health in both research, policy, and program development.

This study can help inform current and future immigration policies to better ensure a wide array of health issues, needs and conditions are captured and met in a timely and routine manner when selecting and screening immigrants. This is particularly important for immigrant sub-populations, such as recent refugee cohorts, who are at greater risk of morbidity than other immigrant categories.

Our findings can also aid policymakers and program planners to develop specific guidelines within the healthcare system and targeted social service programs for more recent immigrant cohorts. Healthcare providers and public health officials should focus on the development of effective health interventions for the prevention and management of chronic health conditions, including healthy lifestyle and behavioural factors, while policy makers can examine existing social assistance and settlement programs, identify, and recommend long-term investments that ensure effective assimilation and integration into Canadian society.

Our findings show that the consideration of immigrant cohorts in research and policy development contextualize how immigrant policies and socio-political factors influence the way in which immigrants settle and integrate in their host country, and ultimately how they experience better or worst health. Future research should further examine the impact of immigrant cohorts to better identify strengths and opportunities in the context of immigration policy and settlement. This approach will enable policy and program planners to tackle and address health inequities that stem from the structural and intermediary determinants that impact health and well-being across the immigrant population.

As such, this study also highlights the critical importance of routine population-based data collection on immigration status to help inform research, policy development, interventions and decision-making that impact long-term decision-making in preventive health and social services.

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CHAPTER 5 - DISCUSSION

5.1 MAIN FINDINGS

The purpose of this dissertation was to identify and address knowledge gaps in the scientific literature on the development of chronic conditions and multimorbidity across immigrant populations in Ontario using population-based immigrant and health data housed at ICES.

We examined nine chronic conditions available from ICES-derived diseased cohorts that included validated cases of asthma, hypertension, diabetes, congestive heart failure, rheumatoid arthritis, acute myocardial infarction, COPD, Crohn's and Colitis, as well as cancer incidence in Ontario from January 1, 1995, to December 31, 2016.

In Chapter 2, we examined the risk of developing a chronic condition, defined as the incidence of one of the nine chronic conditions, across different immigrant populations, compared to long-term residents. We also examined the unadjusted incidence of developing each individual chronic condition and performed sensitivity analyses by excluding hypertension and diabetes from our main outcome measure.

In Chapter 3, we examined the risk of multimorbidity as having two or more (2+ multimorbidity) and three or more (3+ multimorbidity) co-occurring chronic conditions among different immigrant groups and long-term residents of Ontario. Using these cut-off points, we described patterns of multimorbidity dyad and triad frequencies across different immigrant populations and long-term residents.

In chapter 4, we examined the impact of immigrant cohorts and the risk of developing a chronic condition (using the same primary outcome measure in chapter 2) across different immigrant populations, and how this risk differed from long-term residents of Ontario.

The chapters in this thesis were presented as individual manuscripts, each addressing the specific research questions of this doctoral dissertation. However, they are also interconnected and together form a complimentary body of work to further our understanding of the risk of chronic disease development and multimorbidity across different immigrant populations by considering both pre- and post-migration factors, such as immigrant visa category, world regions of origin and other sociodemographic characteristics combined. Knowledge generated from this work will inform policies and evidence-based decision-making aimed to address and reduce chronic diseases and health disparities.

The principal findings of this dissertation are:

<u>The risk of developing a chronic condition varied by the type of chronic conditions examined in chapter 2.</u>

- Our unadjusted analyses of individual chronic condition incidence showed that all classes of immigrants had a higher risk of developing diabetes compared to long-term residents of Ontario.
- Refugee and family class immigrants had an elevated risk of hypertension and asthma incidence compared to long-term residents.
- All immigrants had lower or similar unadjusted risk of developing a chronic condition, compared to long-term Ontario residents, when hypertension and diabetes were not included in the outcome variable.

<u>The adjusted risk of developing a chronic condition was complex and varied by an immigrants' visa category and world region origin.</u>

- Refugees had the highest risk of developing a chronic condition, family immigrants showed no differences, and economic immigrants had a lower risk compared to long-term Ontario residents after controlling for age, sex, and neighborhood level income quintiles.

- There were differences in the risk of developing a chronic condition, within the same world regions of origin, when examined across different immigrant categories, described in chapter 2.

The risk of and patterns of multimorbidity varied by immigrants' visa category and world regions of origin.

- Our descriptive analysis of multimorbidity patterns in chapter 3 showed hypertension and diabetes, and in combination with COPD were the leading multimorbidity dyad and triad groups for all immigrant categories and long-term residents of Ontario.
- Refugees had a higher adjusted risk of 2+ multimorbidity compared to long-term residents, controlling for age, sex, and neighborhood level income quintiles.
- Our multivariate analyses showed that immigrants from the Caribbean and South Asia had a higher adjusted risk of 2+ multimorbidity, irrespective of their immigrant category. All immigrants from East Asia and the Pacific and Eastern Europe and Central Asia had lower risk compared to long-term residents.
- The adjusted risk of multimorbidity, by certain world regions of origin, varied by an immigrants' visa category.
- Refugee and family immigrants from South Asia and refugees from North Africa and the Middle East had a greater adjusted risk of 3+ multimorbidity, compared to long-term residents in our multivariate findings.

The adjusted risk of developing a chronic condition increased among immigrants in more recent landing cohorts.

- More recent refugees had the highest adjusted risk compared to those who landed in earlier cohorts, controlling for age, sex, neighborhood level income quintiles and world regions of origin.

- Family and economic class immigrants had a lower adjusted risk of developing a chronic condition compared to long-term residents in our multivariate findings. Their risk was lower across all landing cohorts, but higher in more recent cohorts, compared to those who landed in earlier landing cohorts.

5.2 RESEARCH IMPLICATIONS FOR POLICY AND PROGRAM PLANNING

Current medical guidelines in Canada are geared towards the care and management of patients with single diseases and are not tailored to meeting the needs of immigrant populations with complex and emerging health issues (Muggah et al., 2012; Pottie et al., 2011). This imposes a challenge for primary health care professionals who try to implement evidence-based guidelines when providing care for immigrant patients with chronic health conditions and multimorbidity (Muggah et al., 2012).

Our findings inform precision planning in public health by highlighting the complexity and heterogeneity of health outcomes across immigrant populations, and the importance of considering the intersecting migration factors that impact and differentiate the health of immigrant populations when developing targeted programs and health policy (Khoury et al., 2016). This requires efforts to analyze individuals and population groups more precisely, and tailor preventive interventions to reduce health disparities (Weeramanthri et al., 2018; Khoury et al., 2016; Baynam et al., 2017).

Our analyses of chronic health outcomes, including individual chronic condition incidence and multimorbidity revealed hypertension and diabetes as potential driving conditions that elevate the risk of chronic health outcomes across different immigrant populations. This was further evident when we examined the incidence of multimorbidity and observed how these two conditions were the most common disease dyads and triads when combined with a third chronic condition in this heterogenous population. In Canada, the incidence of multimorbidity is increasing due in part to an

increased rate of individual chronic conditions such as diabetes and hypertension (Van Den Akker, Buntinx, Roos, & Knottnerus, 2001). These trends are consistent with findings presented in this dissertation and highlight the need to consider developing primary health care programs geared towards the prevention and management of these conditions and tailored towards immigrant populations.

The primary health care system plays a critical role in the management of chronic conditions, including health promotion and disease prevention across various populations. The rising number of chronic conditions and multimorbidity will have significant financial and system-wide impacts relevant to primary health care policy and practice (Muggah et al., 2012). It is important to develop preventative measures and design health promotion programs, that are culturally sensitive and tailored to different populations (Diaz, Ortiz-Barreda et al, 2017; Iron et al., 2011; Muggah et al., 2012).

Findings from this study highlight the need to better understand both the clinical and healthcare system impacts of emerging and complex health needs of immigrant populations, and inform the need to develop guidelines and standards of care, including improvements to existing health care programs and services for this growing and diverse population (Muggah et al., 2012).

This thesis further demonstrated how immigrant cohorts reveal important differences in health outcomes. It highlights the need to consider the impact of cohorts in research, policy, and program development, by contextualizing how immigrant policies and socio-political factors, as conceptualized in our application of the CSDH framework to immigrant populations, influence the way in which immigrants settle and integrate in their host country, and ultimately how they experience better or worse health. Policy analysts and decision-makers should further examine the impact of immigrant cohorts to better identify strengths and opportunities in the context of immigration policy and settlement.

Addressing the health needs of immigrant populations will also require efforts across all levels of government that include improving programs and policies that extend beyond the healthcare system and address inequities embedded in the structural and intermediary determinants of health. Existing medical screening guidelines of immigrants have focused primarily on communicable diseases. However, given the rising global rates of chronic diseases, there is a need to ensure a wide array of health issues, needs and conditions are captured in a timely and routine manner for prevention and planning purposes (Pottie et al., 2011). This is particularly important for immigrant sub-populations, such as refugees, who are at greater risk of morbidity than other immigrant categories.

Our findings can also aid policymakers and program planners to develop specific guidelines within the healthcare system and targeted social service programs for immigrant sub-populations at greater risk, such as recent refugees and immigrants from various world regions of origin.

Healthcare providers and public health officials should focus on the development of effective health interventions for the prevention and management of chronic health conditions, including healthy lifestyle and behavioural factors, while policy makers can examine existing social assistance and settlement programs, identify, and recommend long-term investments that ensure effective assimilation and integration into Canadian society.

5.3 FUTURE RESEARCH DIRECTIONS

Future studies should examine the impact of common treatments of multiple chronic conditions, that are not siloed towards singular diseases, using large population based data that informs precision planning (Khoury et al., 2016) and identify best practices and opportunities for further research, policy and program development across different immigrant populations (Diaz, Ortiz-Barreda et al, 2017; Iron et al., 2011).

Our immigrant cohort, derived from the IRCC database, contained 2.64% of the immigrant population classified as "Other", representing a small but diverse population of other immigrant categories under current Canadian immigration classification (Appendix C). We were unable to ascertain the risk for "Other" immigrant categories, due to their small sample size, and did not include them in our study population and analyses. However, we conducted separate analyses that revealed a similar risk as refugees for developing a chronic condition and multimorbidity when compared to long-term Ontario residents. Future studies should further investigate the characteristics of the "Other" group.

Our data contained refugees that were sponsored by the government of Canada or privately by citizens and organization groups from Canada. However, the '*Refugees landed in Canada'* category is for those refugees who are successful in their asylum claims and the '*Refugee dependent'* category is also not considered government or private sponsored, as listed in Appendix C.

The refugee population within our sample was amongst the smallest in our immigrant cohort. It was not within the scope of this dissertation to examine differences between refugee sub-groups. However, there are important differences in pathways to permanent residency and differing periods of having obtained Canadian healthcare prior to OHIP registration (e.g., IFHP), for those in the refugee landed and dependent categories, compared to resettled refugees. Future research should examine longitudinal differences in risk, over time, after settlement in Canada to investigate potential differences in health outcomes and risk of developing chronic conditions that may be impacted by contextual factors related to the source of their sponsorship and settlement in Canada.

This study focused only on first-generation immigrations in an adult population 18 to 70 years of age. Future studies should aim to capture second generation immigrants, and examine migrant health across the lifespan, particularly immigrant children from world regions of origin with greater risk of developing a chronic condition and multimorbidity.

Future studies need to better examine acculturative stress processes, particularly changes in lifestyle and behavioural factors that impact health over time for immigrants in host countries, and how sociocultural factors protect immigrants from morbidity (Rote & Markides, 2015; Beiser, 2005)

5.4 **STRENGTHS**

This study's main strength is that it examines a diverse immigrant population who migrated at different points in time, from different world regions of origin, and their risk of developing a chronic condition and multimorbidity utilizing population-based administrative health and immigrant data available at ICES. A detailed profile of risk patterns across all immigrant visa categories, and further by world regions of origin, on several population-based chronic health conditions has been lacking in Canada.

Previous studies have lacked information such as exact year of landing, region of origin or immigrant category (Antecol & Bedard, 2015; Ro et al., 2015). They have either investigated the relationship between ethnicity and health (Stevenson et al., 2018; Deb et al., 2016; Ginsburg et al., 2015; Mukerji, Chiu, Shah, 2012; Shah et al, 2010; Rosella et al., 2012) the association between migration, health and ethnicity whereby treating 'immigrants' as a homogeneous group (Di Giuseppe et al., 2019; Iqbal et al., 2017; Tu et al., 2015; Creatore, 2010) or used cross-sectional or survey data that either lacked sufficient sample sizes, or unable to establish a causal relationship due to limitations in study design (Beiser and Hou, 2014; Reed & Barbosa, 2017).

This study overcame previous methodological challenges by conducting stratified analyses on important migration characteristics using a longitudinal study design over a 20-year period. This study is also among the first to estimate the incidence of a chronic condition and multimorbidity among a healthy cohort of immigrants in Canada. Previous research has largely focused on calculating the prevalence of multimorbidity, with limited ability to distinguish when the co-occurring conditions developed (Roberts et al., 2015).

We were able to follow a healthy cohort of immigrants to examine the risk of developing a chronic condition and multimorbidity with the ability to distinguish whether diagnoses of chronic health conditions developed after immigrating to Canada. Our healthy cohort of immigrants were disease-free three years after landing in Canada and were matched to a disease-free long-term resident of Ontario. This approach enabled us to ascertain differences in the risk of chronic condition outcomes, among different immigrant cohorts after arrival, by excluding immigrants who came to Canada with an existing chronic condition prior to settlement.

Our study used nine chronic health conditions from ICES-derived disease cohorts that were defined from previously validated population-derived cohorts using linked data algorithms from a combination of hospital, emergency department, and outpatient data. The algorithms specify a combination of a certain number of records, coupled with diagnostic codes that must have occurred within a certain time-period. Validation for these cohorts involve medical chart review and report several measures of validity (refer to Appendix E).

Moreover, this study utilized population-based administrative data to inform the development of evidence-informed policy and decision-making on the healthcare needs of immigrant populations, with various chronic conditions (Iron, Lu, Manuel, Henry, & Gershon, 2011). The use of linked-population data enabled us to obtain a broad view of immigrant health and complex chronic diseases across this heterogenous population. Administrative data are reliable tools for surveillance and planning, available in a timely manner and provide population-level information (Verning &McBean, 2001). Findings generated from the use of administrative, population-based data can be used by governments, planners, and health care professionals to guide decision-making, develop policies and inform changes in health care delivery at a population health level (ICES, 2019).

5.5 **LIMITATIONS**

Limitations do exist; however, we were unable to examine the impact of all chronic conditions across immigrant populations. Mental health conditions were not captured in our disease cohorts and are an important factor to consider when studying migrant health (Kirmayer et al., 2011). This is particularly important for immigrant populations at greater risk of morbidity, such as refugees, given their health disadvantage upon arrival and pre-migratory exposures to violence, disease and stress (Hollander et al., 2012; Hollander, Bruce, Burström, & Ekblad, 2013; Reed & Barbosa, 2017; Hyman, 2010). Therefore, our findings may underestimate the immigrant populations' risk of developing a chronic condition and multimorbidity, particularly among certain immigrant sub-groups. Moreover, since most chronic condition algorithms used in the ICES-derived disease cohorts favor specificity over sensitivity, under-estimation of the risk of may persist (ICES, 2019).

In this dissertation, we defined multimorbidity as two or more and three or more co-occurring chronic conditions, approaches that have commonly been applied in prior research (Boyd and Fortin, 2010; Tetzlaff et al., 2017). However, no universal definition currently exists, nor a consensus on the kinds of chronic conditions or health impairments that constitute multimorbidity (Tetzlaff et al., 2017). Methods for defining and measuring multimorbidity are evolving (Ryan et al., 2018; Smith, Soubhi, Fortin, Hudon, & O'Dowd, 2012b). Researchers have used counts of chronic conditions, others have included symptoms and/or risk factors, or combined quantity and severity of diseases using weighted index measures (Boyd and Fortin, 2010; Willadsen et al., 2016).

Canada's tri-council funders and the government of Canada recommend sex and gender-based analyses in research studies (Canadian Institutes of Health Research, 2019). We conducted some sex-stratified descriptive and multivariate regression analyses to examine differences in our

outcome measures of interest by sex but did not report extensive findings in the chapters of this dissertation. Appendix I presents sex-stratified results for select analyses from chapters 2 and 3.

When comparing the risk of developing a chronic condition, there were no statistically significant differences by sex, after conducting sex-stratified analyses for each immigrant visa category. When we examined our outcome measure, by world region of origin, women from the Caribbean had a higher risk of developing a chronic condition, compared to men, for each immigrant category. This finding is consistent with previous research that examined the prevalence and risk of diabetes using immigrant data from ICES data (Creatore, 2013).

We also found no statistically significant differences in the risk of developing multimorbidity (two or more as well as three or more co-occurring chronic conditions) when conducting sex-stratified analyses for each immigrant category, and further by world regions of origin.

Our study lacked social determinants of health (e.g., smoking, diet, physical activity, alcohol consumption, occupation), patterns of health seeking behaviours, barriers to care and mechanisms of disease and included migrant characteristics and neighborhood-level income profiles at the time of their arrival or 3-years following their landing, respectively. Socio-economic factors, such as income are important determinants of health that can impact both settlement and health outcomes over time, following an immigrant's arrival to Canada.

Lastly, our use of administrative health data relies on the quality of the data recorded which is a common limitation for studies that use routinely collected health information (Barnett et al., 2012; Diaz, Poblador-Pou, et al., 2015).

5.6 **CONCLUSIONS**

This doctoral dissertation provides evidence to inform precision planning in public health and preventive medicine by highlighting the complexity and heterogeneity of health outcomes across

immigrant populations. Findings from this dissertation can inform the development of targeted health programs and policies aimed to reduce population health disparities.

The knowledge generated from this dissertation further contributes to our understanding and consideration of immigrant cohorts in research, policy and program development, by contextualizing how immigrant policies and socio-political factors influence the way in which immigrants settle and integrate in their host country, and ultimately how they experience better or worst health.

Addressing the health needs of immigrant populations will require efforts across all levels of government that include improving programs and policies extending beyond the healthcare system. This is particularly important for immigrant sub-populations, such as recent refugees, who are at greater risk of morbidity than other immigrants as shown by this research.

Finally, this doctoral dissertation highlights the importance of routine population-based data collection on immigration status and ethnicity/region of origin to help inform research, policy development, interventions and precision-planning that impact long-term investments in preventive medicine, chronic health management and social services.

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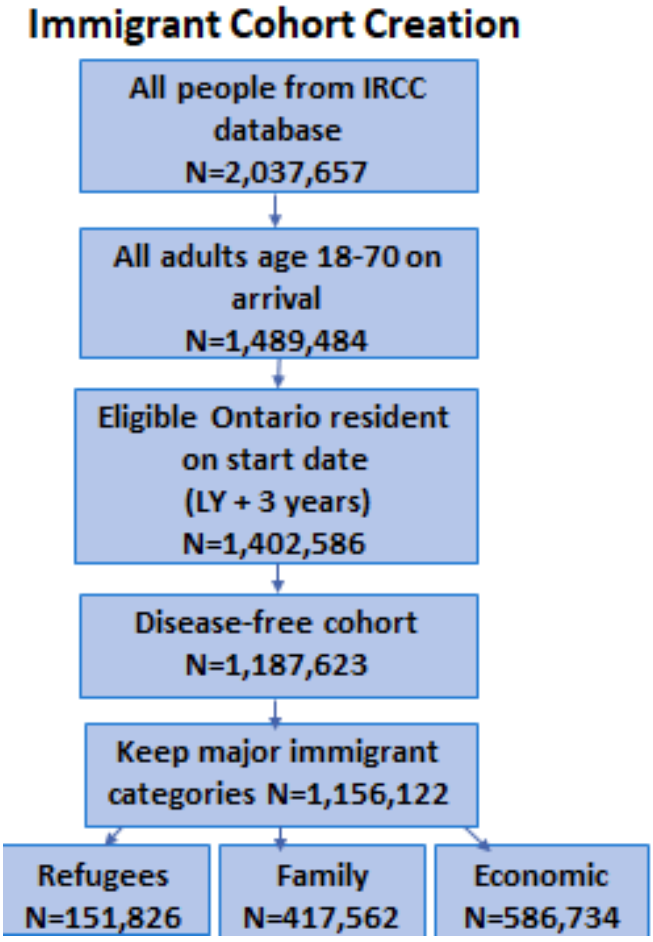
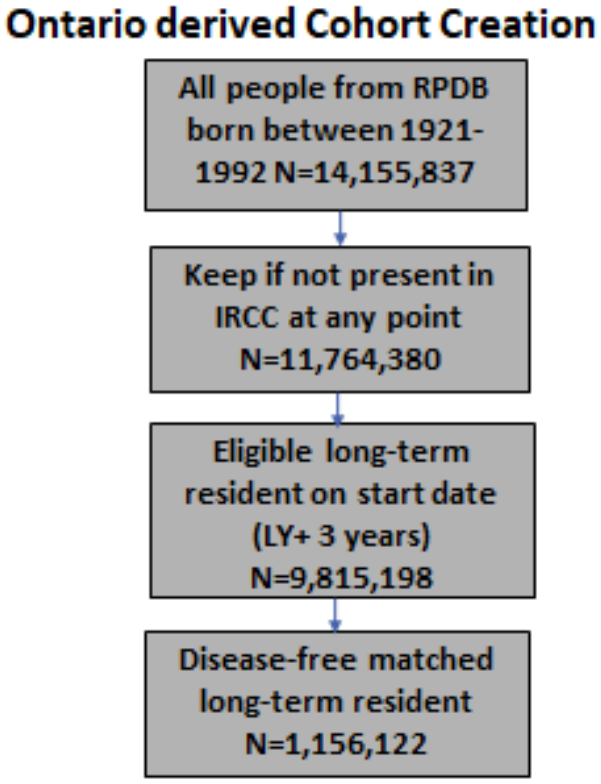
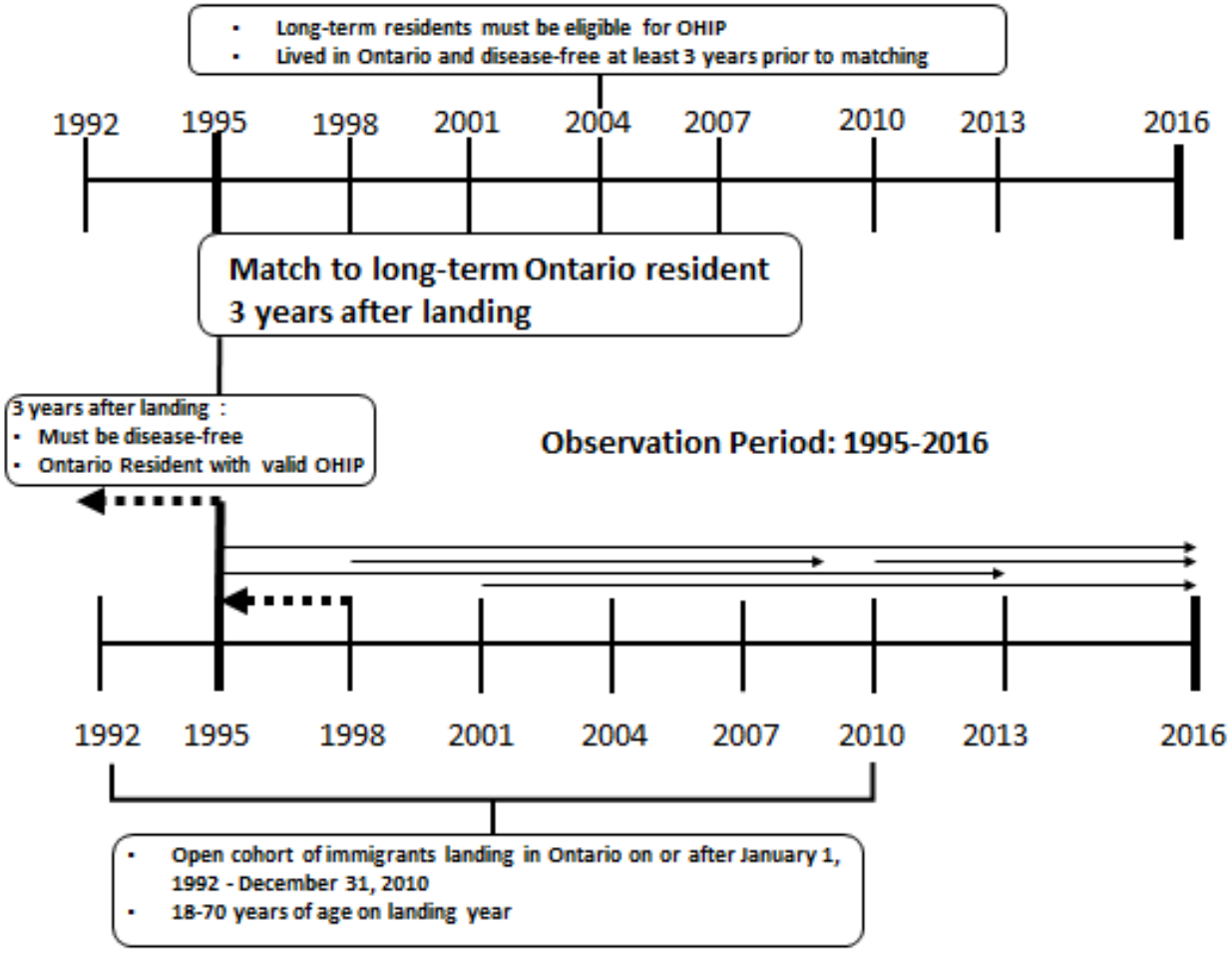
APPENDICES

6.1 APPENDIX A. IMMIGRANT AND LONG-TERM ONTARIO RESIDENT COHORT CREATION





6.2 APPENDIX B. PROCESS OF MATCHING IMMIGRANTS TO LONG-TERM RESIDENTS



6.3 APPENDIX C. IMMIGRANT VISA CLASSIFICATION INCLUDED IN THE IMMIGRANT, REFUGEES AND CITIZENSHIP CANADA DATABASE AND THE ASSIGNED IMMIGRANT CATEGORY

Immigation Visa Classification

Variable Name:	**FCLAS**	
Label:	**Immigration Class**	
FCLAS code from CIC data	**Immigration Class Name**	**Assigned Immigrant Category**
023	Canadian Experience Class - p.a.	Economic
024	Canadian Experience Class - s.d.	Economic
053	Caregivers - p.a.	Economic
054	Caregivers - s.d.	Economic
011	Entrepreneurs - p.a.	Economic
012	Entrepreneurs - s.d.	Economic
015	Investors - p.a.	Economic
016	Investors - s.d.	Economic
017	Investor Venture Capital - p.a.	Economic
018	Investor Venture Capital - s.d.	Economic
051	Live-in caregivers - p.a.	Economic
052	Live-in caregivers - s.d.	Economic
041	Provincial/territorial nominees - p.a.	Economic
042	Provincial/territorial nominees - s.d.	Economic
061	Retirees - p.a.	Economic
062	Retirees - s.d.	Economic
013	Self-employed - p.a.	Economic
014	Self-employed - s.d.	Economic
021	Skilled workers - p.a.	Economic
022	Skilled workers - s.d.	Economic
025	Skilled trades - p.a.	Economic
026	Skilled trades - s.d.	Economic
001	Spouses and partners	Family
019	Start-up Business - p.a.	Economic

Immigation Visa Classification

Variable Name:	**FCLAS**	
Label:	**Immigration Class**	
FCLAS code from CIC data	**Immigration Class Name**	**Assigned Immigrant Category**
020	Start-up Business - s.d.	Economic
002	Fiancé(e)s	Family
004	Parents and grandparents	Family
003	Sons and daughters	Family
-01	Category not stated	Other
063	DROC and PDRCC - p.a.	Other
064	DROC and PDRCC - s.d.	Other
066	H and C cases	Other
067	Other H and C cases outside the family class / Public Policy	Other
005	Others	Other
070	Public Policy with RAP	Other
071	Public Policy without RAP	Other
065	Temporary resident permit holders	Other
035	Blended Visa Office-Referred refugees	Refugee
031	Government-assisted refugees	Refugee
032	Privately sponsored refugees	Refugee
034	Refugee dependants	Refugee
033	Refugees landed in Canada	Refugee

6.4 APPENDIX D. COUNTRIES INCLUDED IN THE IMMIGRANT, REFUGEES AND CITIZENSHIP CANADA DATABASE AND THE ASSIGNED WORLD REGIONS OF ORIGIN

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
620	Anguilla	Caribbean
621	Antigua And Barbuda	Caribbean
658	Aruba	Caribbean
622	Bahama Islands, The	Caribbean
610	Barbados	Caribbean
601	Bermuda	Caribbean
624	Cayman Islands	Caribbean
650	Cuba	Caribbean
625	Dominica	Caribbean
651	Dominican Republic	Caribbean
626	Grenada	Caribbean
653	Guadeloupe	Caribbean
654	Haiti	Caribbean
602	Jamaica	Caribbean
655	Martinique	Caribbean
627	Montserrat	Caribbean
652	Netherlands Antilles, The	Caribbean
628	Nevis	Caribbean
899	Ocean Nes	Caribbean
656	Puerto Rico	Caribbean
629	St. Kitts-Nevis	Caribbean
630	St. Lucia	Caribbean
631	St. Vincent and the Grenadines	Caribbean

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
605	Trinidad & Tobago, Republic of	Caribbean
632	Turks and Caicos Islands	Caribbean
633	Virgin Islands, British	Caribbean
657	Virgin Islands, U.S.	Caribbean
299	Asia Nes	East Asia and the Pacific
399	Australia Nes	East Asia and the Pacific
256	Cambodia	East Asia and the Pacific
202	China, People's Republic of	East Asia and the Pacific
840	Cook Islands	East Asia and the Pacific
916	East Timor, Democratic Republic of	East Asia and the Pacific
835	Federated States of Micronesia	East Asia and the Pacific
801	Fiji	East Asia and the Pacific
845	French Polynesia	East Asia and the Pacific
832	Guam	East Asia and the Pacific
204	Hong Kong	East Asia and the Pacific
200	Hong Kong Sar	East Asia and the Pacific
222	Indonesia, Republic of	East Asia and the Pacific
207	Japan	East Asia and the Pacific
831	Kiribati	East Asia and the Pacific
257	Korea, People's Democratic Republic of	East Asia and the Pacific
258	Korea, Republic of	East Asia and the Pacific
260	Laos	East Asia and the Pacific
261	Macao	East Asia and the Pacific
172	Madagascar	East Asia and the Pacific
242	Malaysia	East Asia and the Pacific
834	Marshall Islands, Republic of	East Asia and the Pacific

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
262	Mongolia, People's Republic of	East Asia and the Pacific
241	Myanmar (Burma)	East Asia and the Pacific
341	Nauru	East Asia and the Pacific
822	New Caledonia	East Asia and the Pacific
830	Pacific Islands, US Trust Territory of the	East Asia and the Pacific
342	Papau New Guinea	East Asia and the Pacific
227	Philippines	East Asia and the Pacific
842	Pitcairn Island	East Asia and the Pacific
903	Reunion	East Asia and the Pacific
843	Samoa, American	East Asia and the Pacific
844	Samoa, Western	East Asia and the Pacific
266	Sikkim (Asia)	East Asia and the Pacific
246	Singapore	East Asia and the Pacific
824	Solomons, The	East Asia and the Pacific
825	Soloman Islands	East Asia and the Pacific
203	Taiwan	East Asia and the Pacific
267	Thailand	East Asia and the Pacific
268	Tibet	East Asia and the Pacific
846	Tonga	East Asia and the Pacific
823	Vanuatu	East Asia and the Pacific
270	Vietnam, Socialist Republic of	East Asia and the Pacific
841	Wallis and Futuna	East Asia and the Pacific
081	Albania	Eastern Europe and Central Asia
049	Armenia	Eastern Europe and Central Asia
050	Azerbaijan	Eastern Europe and Central Asia
051	Belarus	Eastern Europe and Central Asia

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
048	Bosnia-Hercegovina	Eastern Europe and Central Asia
083	Bulgaria	Eastern Europe and Central Asia
043	Croatia	Eastern Europe and Central Asia
070	Fyr Macedonia	Eastern Europe and Central Asia
052	Georgia	Eastern Europe and Central Asia
025	Greece	Eastern Europe and Central Asia
026	Hungary	Eastern Europe and Central Asia
053	Kazakhstan	Eastern Europe and Central Asia
054	Kyrgyzstan	Eastern Europe and Central Asia
019	Latvia	Eastern Europe and Central Asia
020	Lithuania	Eastern Europe and Central Asia
055	Moldova	Eastern Europe and Central Asia
033	Poland	Eastern Europe and Central Asia
088	Romania	Eastern Europe and Central Asia
056	Russia	Eastern Europe and Central Asia
016	Slovak Republic	Eastern Europe and Central Asia
047	Slovenia	Eastern Europe and Central Asia
057	Tadjikistan	Eastern Europe and Central Asia
045	Turkey	Eastern Europe and Central Asia
058	Turkmenistan	Eastern Europe and Central Asia
059	Ukraine	Eastern Europe and Central Asia
042	Union of Soviet Socialist Republics	Eastern Europe and Central Asia
060	Uzbekistan	Eastern Europe and Central Asia
044	Yugoslavia	Eastern Europe and Central Asia
703	Argentina	Latin America
541	Belize	Latin America

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
751	Bolivia	Latin America
709	Brazil	Latin America
549	Central America NES	Latin America
721	Chile	Latin America
722	Colombia	Latin America
542	Costa Rica	Latin America
753	Ecuador	Latin America
543	El Salvador	Latin America
754	French Guiana	Latin America
544	Guatemala	Latin America
711	Guyana	Latin America
545	Honduras	Latin America
501	Mexico	Latin America
546	Nicaragua	Latin America
548	Panama Canal Zone	Latin America
547	Panama, Republic of	Latin America
755	Paraguay	Latin America
723	Peru	Latin America
799	South America NES	Latin America
752	Surinam	Latin America
724	Uruguay	Latin America
725	Venezuela	Latin America
699	West Indies NES	Latin America
131	Algeria	North Africa and the Middle East
253	Bahrain	North Africa and the Middle East
255	Brunei	North Africa and the Middle East

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
183	Djibouti, Republic of	North Africa and the Middle East
101	Egypt	North Africa and the Middle East
223	Iran	North Africa and the Middle East
224	Iraq	North Africa and the Middle East
206	Israel	North Africa and the Middle East
225	Jordan	North Africa and the Middle East
226	Kuwait	North Africa and the Middle East
208	Lebanon	North Africa and the Middle East
171	Libya	North Africa and the Middle East
133	Morocco	North Africa and the Middle East
263	Oman	North Africa and the Middle East
213	Palestinian Authority (Gaza/West Bank)	North Africa and the Middle East
265	Qatar	North Africa and the Middle East
231	Saudi Arabia	North Africa and the Middle East
210	Syria	North Africa and the Middle East
135	Tunisia	North Africa and the Middle East
280	United Arab Emirates	North Africa and the Middle East
274	Yemen, People's Democratic Republic of	North Africa and the Middle East
273	Yemen, Republic of	North Africa and the Middle East
252	Afghanistan	South Asia
212	Bangladesh	South Asia
254	Bhutan	South Asia
205	India	South Asia
901	Maldives, Republic of	South Asia
264	Nepal	South Asia
209	Pakistan	South Asia

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
201	Sri Lanka	South Asia
199	Africa Nes	Sub-Saharan Africa
151	Angola	Sub-Saharan Africa
160	Benin, Peoples Republic of	Sub-Saharan Africa
153	Botswana	Sub-Saharan Africa
188	Burkino-Faso	Sub-Saharan Africa
154	Burundi	Sub-Saharan Africa
155	Cameroon, Federal Republic of	Sub-Saharan Africa
911	Cape Verde Islands	Sub-Saharan Africa
157	Central Africa Republic	Sub-Saharan Africa
156	Chad, Republic of	Sub-Saharan Africa
905	Comoros	Sub-Saharan Africa
159	Congo, People's Republic of the	Sub-Saharan Africa
158	Congo, Democratic Republic of	Sub-Saharan Africa
162	Eritrea	Sub-Saharan Africa
161	Ethiopia	Sub-Saharan Africa
163	Gabon Republic	Sub-Saharan Africa
164	Gambia	Sub-Saharan Africa
165	Ghana	Sub-Saharan Africa
178	Guinea, Equatorial	Sub-Saharan Africa
166	Guinea, Republic of	Sub-Saharan Africa
167	Guinea-Bissau	Sub-Saharan Africa
169	Ivory Coast, Republic of	Sub-Saharan Africa
132	Kenya	Sub-Saharan Africa
152	Lesotho	Sub-Saharan Africa
170	Liberia	Sub-Saharan Africa

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
111	Malawi	Sub-Saharan Africa
173	Mali, Republic of	Sub-Saharan Africa
174	Mauritania	Sub-Saharan Africa
902	Mauritius	Sub-Saharan Africa
175	Mozambique	Sub-Saharan Africa
122	Namibia	Sub-Saharan Africa
176	Niger, Republic of the	Sub-Saharan Africa
177	Nigeria	Sub-Saharan Africa
179	Rwanda	Sub-Saharan Africa
914	Sao Tome e Principe	Sub-Saharan Africa
180	Senegal	Sub-Saharan Africa
904	Seychelles	Sub-Saharan Africa
181	Sierra Leone	Sub-Saharan Africa
182	Somalia, Democratic Republic of	Sub-Saharan Africa
121	South Africa, Republic of	Sub-Saharan Africa
185	Sudan, Democratic Republic of	Sub-Saharan Africa
186	Swaziland	Sub-Saharan Africa
130	Tanzania, United Republic of	Sub-Saharan Africa
187	Togo, Republic of	Sub-Saharan Africa
136	Uganda	Sub-Saharan Africa
184	Western Sahara	Sub-Saharan Africa
112	Zambia	Sub-Saharan Africa
113	Zimbabwe	Sub-Saharan Africa
979	Stateless	Unknown Origin
000	Unknown	Unknown Origin
082	Andorra	Western Europe & U.S.

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
305	Australia	Western Europe & U.S.
011	Austria	Western Europe & U.S.
035	Azores	Western Europe & U.S.
012	Belgium	Western Europe & U.S.
003	British Citizen	Western Europe & U.S.
005	British Dependent Territories Citizen	Western Europe & U.S.
010	British National Overseas	Western Europe & U.S.
004	British Overseas Citizen	Western Europe & U.S.
511	Canada	Western Europe & U.S.
039	Canary Islands	Western Europe & U.S.
009	Channel Islands	Western Europe & U.S.
221	Cyprus	Western Europe & U.S.
015	Czech Republic	Western Europe & U.S.
014	Czechoslovakia	Western Europe & U.S.
017	Denmark	Western Europe & U.S.
002	England	Western Europe & U.S.
018	Estonia	Western Europe & U.S.
099	Europe Nes	Western Europe & U.S.
912	Falkland Islands	Western Europe & U.S.
021	Finland	Western Europe & U.S.
022	France	Western Europe & U.S.
046	German Democratic Republic	Western Europe & U.S.
024	Germany, Federal Republic of	Western Europe & U.S.
084	Gibraltar	Western Europe & U.S.
521	Greenland	Western Europe & U.S.
090	Holy See	Western Europe & U.S.

Countries in IRCC Database

Variable Name: **FCOB**

Label: **Country of birth**

FCOB code from CIC data	Country Name	Assigned World Region of Origin
085	Iceland	Western Europe & U.S.
027	Ireland, Republic of	Western Europe & U.S.
028	Italy	Western Europe & U.S.
086	Liechtenstein	Western Europe & U.S.
013	Luxembourg	Western Europe & U.S.
036	Madeira	Western Europe & U.S.
030	Malta	Western Europe & U.S.
906	Mayotte	Western Europe & U.S.
087	Monaco	Western Europe & U.S.
031	Netherlands, The	Western Europe & U.S.
512	Newfoundland	Western Europe & U.S.
339	New Zealand	Western Europe & U.S.
006	Northern Ireland	Western Europe & U.S.
032	Norway	Western Europe & U.S.
034	Portugal	Western Europe & U.S.
089	San Marino	Western Europe & U.S.
007	Scotland	Western Europe & U.S.
821	Southern Antarctic Territories	Western Europe & U.S.
037	Spain	Western Europe & U.S.
915	St. Helena	Western Europe & U.S.
531	St. Pierre et Miquelon	Western Europe & U.S.
040	Sweden	Western Europe & U.S.
041	Switzerland	Western Europe & U.S.
826	Tuvalu	Western Europe & U.S.
461	United States of America	Western Europe & U.S.
001	United Kingdom and Colonies	Western Europe & U.S.

Countries in IRCC Database

Variable Name:	**FCOB**	
Label:	**Country of birth**	
FCOB code from CIC data	**Country Name**	**Assigned World Region of Origin**
008	Wales	Western Europe & U.S.

6.5 APPENDIX E. ICES-DERIVED AND ACQUIRED DISEASE COHORTS/REGISTRIES

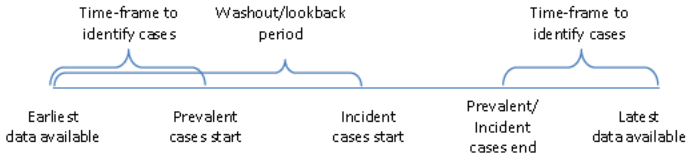
ICES-derived Disease Cohorts

Note: The following information was directly derived from the ICES data dictionary *"Validated ICES-derived cohorts V.2"* (ICES, 2019).

The ICES-derived cohorts are datasets that have been created at ICES by utilizing validated case-finding algorithms to identify individuals with specific diseases. These algorithms use a combination of hospital, emergency department, and outpatient data, and in some instances drug claim information. They specify a combination of a certain number of records, coupled with diagnostic codes, that must have occurred within a certain time period. The validation studies for these disease cohorts involve medical chart reviews and report several validation measures (see below).

All the datasets contain both prevalent and incident cases from the beginning of the case-finding period. The number of prevalent cases is low in the beginning of the timeframe and high closer to the present, since cases that have survived are carried forward in time. For prevalence cohorts, the date when an individual meets the case definition criteria does not equal the date of diagnosis (e.g., a person could have been diagnosed many years prior to the data availability, yet we are only capturing their recent contact with the healthcare system). Some of the derived cohorts offer methods to examine incident cases by specifying a "***washout/lookback***" period, or by using the earliest available contact date, which ensures an equal amount of time for case-finding and guarantees that cases are not carried forwards without having recent contact with the healthcare system. Note that the "washout/lookback" period is only used once, in the beginning of the observation period, to ensure cases are incident (i.e., new); the cases then carry forward until death, similarly to prevalent cases.

Cases may be flagged from the earliest time when data are available (e.g., 1988 for hospitalizations, 1991 for OHIP claims). The full algorithm timeframe then must elapse before prevalent cases can be identified (e.g., if the algorithm specifies a two-year period for OHIP claims or hospitalizations, prevalent cases can be identified in 1993). For incident cases, a washout/lookback period is specified (e.g., incident cases can be identified from 1995 based on a four-year washout/lookback period). The same pre-specified period would need to be counted from the end of available data, in order to ensure equal case-finding periods (e.g., if data end in 2016, the last prevalent case can be identified in 2014 – the number of patients is altered as we receive more data).



The algorithms may change over time or may differ by age groups or disease presentations. Additionally, some derived cohorts involve both a 'sensitive' and a 'specific' definition. The sensitive definition in this context typically includes a broader definition of diagnostic codes, or a more 'relaxed' method of identifying a case (e.g., fewer outpatient visits required in a certain timeframe).

Abbreviations: OHIP, Ontario Health Insurance Plan claim; Hosp, hospitalization (CIHI-DAD/SDS); OMHRS, Ontario Mental Health Reporting System; ED, emergency department visit (NACRS); PPV, positive predictive value; NPV, negative predictive value; DOLC, date of last contact with the healthcare system; Dx, diagnosis. Note: If a validation study cited below used more than one reference standard, validation measures are provided only for the chart review gold standard.

Validation measures:

- **Sensitivity**: If a person has the disease according to the Gold Standard (e.g., chart review), how often will the case definition algorithm identify the person as having the disease (i.e., true positive)? *Sensitivity = a/(a+c)*
- **Specificity**: If a person does not have the disease according to the Gold Standard (e.g., chart review), how often will the case definition algorithm identify the person as not having the disease (i.e., true negative)? *Specificity = d/(b+d)*
- **Positive predictive value (PPV):** If the case definition algorithm identifies the person as having the disease, what is the probability of the person actually having the disease, according to the Gold Standard (e.g., chart review)? *PPV = a/(a+b)*
- **Negative predictive value (NPV):** If the case definition algorithm identifies the person as not having the disease, what is the probability of the person actually not having the disease, according to the Gold Standard (e.g., chart review)? *NPV = d/(c+d*

	Gold standard +	Gold standard -
Algorithm +	a	b
Algorithm -	c	d

Name	Database and years	Case definition	Original Validation measures	References	Notes
Asthma	**ASTHMA*** - Data extraction dates: DAD: Apr 1, 1991 to Mar 31, 2017; SDS: Apr 1, 1991 to Mar 31, 2017; OHIP: Jul 1, 1991 to Mar 31, 2017 - Prevalence yearly flags: 1993 to 2016 - Incidence yearly flags: 1996 to 2016	**Sensitive cohort (all ages):** ≥1 Hosp *or* ≥2 OHIP in a two-year period **Specific cohort (all ages):** ≥1 Hosp *or* ≥3 OHIP in a two-year period	**Sensitive cohort (18+):** - 80.6% Sensitivity - 81.4% Specificity - 72.5% PPV, 87.3% NPV **Specific cohort (18+):** - 67.9% Sensitivity - 89.8% Specificity - 80.1% PPV, 82.1% NPV	Gershon AS, Wang C, Guan J, Vasilevska-Ristovska J, Cicutto L, To T. **Identifying patients with physician-diagnosed asthma in health administrative databases.** Can Respir J 2009; 16:183-8. Andrea S. Gershon, Jun Guan, Chengning Wang, Teresa To; **Trends in Asthma Prevalence and Incidence in Ontario, Canada, 1996–2005: A Population Study.** Am J Epidemiol 2010; 172 (6): 728-736. doi: 10.1093/aje/kwq189 T, Dell S, Dick P, et al. **Defining asthma in children for surveillance**, Am J Respir Crit Care Med, 2004, vol. 169 7pg. A383	• 5-year washout/lookback for incidence • While case- ascertainment algorithms are for all ages, validation studies were carried out separately in children/youth and in adults.

Name	Database and years	Case definition	Original Validation measures	References	Notes
Congestive heart failure	**CHF*** - Data extraction dates: DAD: Apr 1, 1988 to Mar 31, 2017; SDS: Apr 1, 1991 to Mar 31, 2017; OMHRS: Oct 1, 2005 to Mar 31, 2017; OHIP: Jul 1, 1991 to Mar 31, 2017 - Prevalence yearly flags: 1991 to 2016 - Incidence yearly flags: 1994 to 2016	**Adults (40+):** ≥1 Hosp (DAD, SDS, OMHRS) *or* 1 OHIP/ED, *followed by* ≥1 Hosp/ED/OHIP within one year	**Adults (40+):** - 84.8% Sensitivity - 97.0% Specificity - 55.6% PPV	Schultz SE, Rothwell DM, Chen Z, Tu K. **Identifying cases of congestive heart failure from administrative data: a validation study using primary care patient records.** Chronic diseases and injuries in Canada 2013; 33:160-6.	• Limited to ages 40+ • Prevalence is re-evaluated annually by examining CONTACT • 3-year washout/lookback for incidence
Crohn's and Colitis Disease	**Adults (18+)** - Data extraction dates: DAD: Apr 1, 19918 to Mar 31, 2017; SDS: Apr 1, 1991 to Mar 31, 2017; OHIP: Jul 1, 1991 to Mar 31, 2017; NACRS: Jul 1, 2000 to Mar 31, 2017; ODB: Apr 1, 1991 to Mar 31, 2017 - Prevalence yearly flags: 1994 to 2016 - Incidence yearly flags: 1999 to 2016	**Adults (18-64):** - Two years of OHIP eligibility *and* ≥5 Hosp/ED/OHIP in a four-year period *OR* - ≥3 Hosp/ED/OHIP in a four-year period (no 2-year OHIP eligibility) **Older adults (65+):** - Two years of OHIP eligibility *and* ≥5 Hosp/ED/OHIP in a four-year period *and* ≥1 ODB claim for IBD medication. *OR* ≥3 Hosp/ED/OHIP in a four-year period *and* ≥1 ODB claim for IBD medication (if no two- year OHIP eligibility)	**Adults (18-64):** - 76.8% Sensitivity - 96.2% Specificity - 81.4% PPV - 95.0% NPV **Older adults (65+):** - 59.3% Sensitivity - 99.0% Specificity - 71.1% PPV - 98.3% NPV	Eric I. Benchimol, Astrid Guttmann, Anne M. Griffiths, Linda Rabeneck, David R. Mack, Herbert Brill, John Howard, Jun Guan, Teresa To, **Increasing incidence of paediatric inflammatory bowel disease in Ontario, Canada: evidence from health administrative data,** GUT, 2009; 58(11): 1490-1497 Eric I. Benchimol, Astrid Guttmann, David R Mack, Geoffrey C Nguyen, John K Marshall, James C Gregor, Jenna Wong, Alan J Forster, Douglas G Manuel, **Validation of international algorithms to identify adults with inflammatory bowel disease in health administrative data from Ontario,** Canada, J Clin Epidemiol. 2014; 67(8):887-96	• 8-year washout/lookback for adult incidence • †OHIP sigmoidoscopy/ colonoscopy fee-code • Note that NACRS starts in 2000

Name	Database and years	Case definition	Original Validation measures	References	Notes
Chronic Obstructive Pulmonary Disease	**COPD*** - Data extraction dates: DAD: Apr 1, 1991 to Mar 31, 2017; SDS: Apr 1, 1991 to Mar 31, 2017; OHIP: Jul 1, 1991 to Mar 31, 2017 - Prevalence yearly flags: 1991 to 2016 -Incidence yearly flags: 1996 to 2016	**Sensitive cohort (35+):** ≥1 Hosp *or* ≥1 OHIP **Specific cohort (35+):** ≥1 Hosp *or* ≥3 OHIP in a two-year period	**Sensitive cohort (35+):** - 85.0% Sensitivity - 78.4% Specificity **Specific cohort (35+):** - 57.5% Sensitivity - 95.4% Specificity	Gershon A, Wang C, Guan J, Vasilevska-Ristovska J, Cicutto L, To T. **Identifying individuals with physcian diagnosed COPD in health administrative databases**. COPD 2009; 6:388-94.	• Limited to ages 35+ • 5-year washout/lookback for incidence
Hypertension	**HYPER*** - Data extraction dates: DAD: Apr 1, 1988 to Mar 31, 2017; SDS: Apr 1, 1991 to Mar 31, 2017; OHIP: Jul 1, 1991 to Mar 31, 2017 - Prevalence yearly flags: 1991 to 2016 - Incidence yearly flags: 1994 to 2016	**Adults (20+):** - ≥1 Hosp *or* ≥2 OHIP in a two-year period. *OR* - 1 OHIP *followed by* OHIP/Hosp within two years. *OR* - 1 Hosp (<1991) *followed by* 1 Hosp (>1991)	**Adults (20+):** - 72% Sensitivity - 95% Specificity - 87% PPV - 88% NPV	Tu K, Campbell NR, Chen Z-L, Cauch-Dudek KJ, McAlister FA. **Accuracy of administrative databases in identifying patients with hypertension.** Open Medicine 2007; 1:18-26. Tu K, Chen Z, Lipscombe LL, Canadian Hypertension Education Program Outcomes Research Taskforce. **Prevalence and incidence of hypertension from 1995 to 2005: a population-based study**. Canadian Medical Association Journal. 2008 May 20;178(11):1429-35.	• 2007 chart abstraction paper looked at ages 35+, 2008 paper looked at ages 20+

Name	Database and years	Case definition	Original Validation measures	References	Notes
Diabetes	**ODD*** - Data extraction dates: DAD: Apr 1, 1991 to Mar 31, 2018; ODB: Apr 1, 1991 to Mar 31, 2018; OHIP: Jul 1, 1991 to Mar 31, 2018 - Prevalence yearly flags: 1991 to 2017 - Incidence yearly flags: 1994 to 2017	**Sensitive cohort (19+):** † - ≥2 OHIP dx 250 in a one-year period *OR* - ≥1 Hosp - *or* ≥1 ODB DM drug claim in a one-year period **Specific cohort (19+):** † - ≥3 OHIP dx 250 in a one-year period	**Sensitive cohort (19+):** - 90.0% Sensitivity - 97.7% Specificity - 82.6% PPV **Specific cohort (19+):** - 79.9% Sensitivity - 99.1% Specificity - 91.4% PPV	Lorraine L. Lipscombe, Jeremiah Hwee, Lauren Webster, Baiju R. Shah, Gillian L. Booth and Karen Tu. **Identifying diabetes cases from administrative data: a population-based validation study.** BMC Health Services Research (2018) 18:316 *Hux JE, Ivis F, Flintoft V, Bica A. Diabetes in Ontario **Determination of prevalence and incidence using a validated administrative data algorithm.** Diabetes care 2002; 25:512-6.	• Algorithm for adult diabetes (sensitive) has been modified, and a specific cohort definition has been added in 2017/18. *The 2002 citation is for the old case definition (retired in 2017/18). Use 2018 citation for new case-definition. • GDM definition changed in 2007 • New OHIP fee-codes added in 2011 • †Distinction b/w paediatric and adult definitions started in 2008 • Excludes OHIP DM • claims during birth • episode and Hosp with gestational diabetes. • Patients may have claims < Dx date

Name	Database and years	Case definition	Original Validation measures	References	Notes
Rheumatoid Arthritis	**ORAD*** - Data extraction dates: DAD: Apr 1, 1988 to Mar 31, 2017; OHIP: Jul 1, 1991 to Mar 31, 2017 - Prevalence yearly flags: 1993 to 2016 - Incidence yearly flags: 1996 to 2016	**Adults (15+):** - ≥1 Hosp with RA dx code (any type): ICD9 714; ICD10 M05, M06 *OR* ≥3 OHIP with RA dx (ICD9 714) in a two-year period (with ≥1 of the claims made by a musculoskeletal specialist – IPDB MAINSPECIALTY Rheumatology, Orthopedic surgery, or Internal medicine)	**Adults (15+):** - 78% Sensitivity - 100% Specificity - 78% PPV - 100% NPV	Widdifield J, Bombardier C, Bernatsky S, Paterson JM, Green D, Young J, Ivers N, Butt DA, Jaakkimainen RL, Thorne JC, Tu K. **An administrative data validation study of the accuracy of algorithms for identifying rheumatoid arthritis: the influence of the reference standard on algorithm performance.** BMC musculoskeletal disorders. 2014 Jun 23;15(1):216. Widdifield J, Bernatsky S, Paterson JM, Tu K, Ng R, Thorne JC, Pope JE, Bombardier C. **Accuracy of Canadian health administrative databases in identifying patients with rheumatoid arthritis: a validation study using the medical records of rheumatologists.** Arthritis care & research. 2013 Oct 1;65(10):1582-91.	• Limited to ages 15+ • In early years rheumatologists may be misclassified as internists (in 2000 onwards, physician incentives for RA- specific codes were introduced) • The indexMSKspecialty variable only provides 1st qualifying specialty • 5-year washout/lookback for incidence
Acute Myocardial Infarction	**OMID*** - Data extraction dates: DAD: Apr 1, 1988 to Mar 31, 2017 (use ADDATE)	**Adults (20+):** - ≥1 Hosp with *most responsible dx* of AMI *and* no AMI Hosp in the previous year	**Adults (20+):** - 88.8% Sensitivity - 92.8% Specificity - 88.5% PPV	Austin PC, Daly PA, Tu JV. **A multicenter study of the coding accuracy of hospital discharge administrative data for patients admitted to cardiac care units in Ontario.** American heart journal 2002; 144:290-6.	This dataset is not comparable to other ICES-derived cohorts – AMI hospitalizations only (no outpatient, no recurrent AMIs within 1 year, no AMI in in-hospital complications).

**Parts of this material are based on data and/or information compiled and provided by CIHI. However, the analyses, conclusions, opinions and statements in the material are those of the author(s), and not necessarily those of CIHI.*

Acquired Cohorts/Registries

Note: The following information was directly derived from the ICES data dictionary *"Ontario Cancer Registry" (updated July 4, 2018)* (ICES, 2018).

Purpose

The Ontario Cancer Registry (OCR) is a computerized database of information on all Ontario residents who have been newly diagnosed with cancer ("incidence") or who have died of cancer ("mortality"). All new cases of cancer are registered, except non-melanoma skin cancer.

While cancer is not a legally reportable disease in Ontario, the Cancer Act provides a legal mandate for Cancer Care Ontario to establish and maintain a cancer registry. Further, under the Cancer Act, any information about a registered case must be kept confidential and not be used or disclosed for any purpose other than for compiling statistics or carrying out medical or epidemiological research."

Data Sources

"The process of cancer registration in Ontario is passive, relying almost completely on records collected for other purposes. Close to 400,000 records are submitted to the OCR each year. Since 1979, the OCR has relied on the same four major data sources:

- hospital discharge and day surgery summaries which include a diagnosis of cancer
- pathology reports with any mention of cancer
- records of patients referred to CCO's eight Regional Cancer Centres or the Princess Margaret Hospital, the specialized institutions treating cancer patients in Ontario
- death certificates, with cancer recorded as the underlying cause of death

All records except pathology reports are coded at the source and provided to the OCR in electronic form. Paper copies of pathology reports are sent to the OCR by hospital and private pathology laboratories and are coded and key-entered by OCR staff into a computerized database.

About ICD-O-3

ICD-O-3 is derived from ICD-10 and is specifically for Oncology coding. This coding system combines topography, histology, and behavior codes.

- Topography: codes that map the human body and indicate the site of origin of a neoplasm (abnormal mass of tissue). These are essentially the subset of ICD-10 "C" codes (e.g., tongue: C02.0-C02.9, C01.9; liver: C22.0, C22.1).
- Histology: in the context of disease coding, histology describes the different appearance and arrangement of cells for different neoplasms.

- Morphology: a code describing the type of cell that has become neoplastic and its biologic activity. This is a 5-digit number; the first 4 digits outline the cell type (histology), and the last digit outlines the behavior (e.g., benign, malignant, metastatic).

References

ICES. (2018). Ontario Cancer Registry (OCR). https://ssl.ices.on.ca/dataprog/Data%20Holdings/Acquired%20Cohorts%20or%20Registries/OCR/,DanaInfo=.aioulhjFpkn2K00Nrq,SSL+index.htm

ICES. (2019). Validated ICES-derived cohorts Document V.2 2019-May-15. https://ssl.ices.on.ca/ResearchData/Data/Documents/,DanaInfo=.arfuhewioHrmp4M22Pts,SSL+Validated%20ICES-derived%20cohorts_post.pdf

6.6 APPENDIX F. LIST OF VARIABLES AND DATA SOURCES

LIST OF VARIABLES AND DATA SOURCES		
VARIABLES	**DESCRIPTION**	**DATA SOURCE**
OUTCOME VARIABLE		
Chronic Health Condition	Diagnosis of at least one of the major chronic conditions (examined as the incidence of one of the 9 listed conditions). See 5.8.	ICES-derived cohorts: ODD (Ontario Diabetes Database), OMID (Ontario Myocardial Infarction Database), ORAD (Ontario Rheumatoid Arthritis Database), Asthma, Congestive Heart Failure (CHF), Ontario Crohn's and Colitis Cohort Database (OCCC), Chronic obstructive pulmonary disease (COPD), stroke Acquired cohorts/registries: OCR (Ontario Cancer Registry) **Note**: Refer to Appendix E
Multimorbidity	Two or more of the listed co-occurring chronic conditions Three or more co-occurring chronic conditions	ICES-derived cohorts: ODD (Ontario Diabetes Database), OMID (Ontario Myocardial Infarction Database), ORAD (Ontario Rheumatoid Arthritis Database), Asthma, Congestive Heart Failure (CHF), Ontario Crohn's and Colitis Cohort Database (OCCC), Chronic obstructive pulmonary disease (COPD), stroke Acquired cohorts/registries: OCR (Ontario Cancer Registry) **Note**: Refer to Appendix E

MAIN EXPOSURE VARIABLE		
Immigrant Status	Binary variable (yes/no) describing whether the individual is born outside of Canada or not	IRCC Database
COVARIATES		
Socio-demographic Variables		
Age	Age of respondent at time of analysis	RPDB
Sex	Sex of respondent at birth	RPDB
Income	Neighborhood level income quintiles	CENSUS and PCCF+
Immigrant-specific Variables		
Immigrant Category	Immigration visa classification variable (FCLAS) at time of landing in Canada – Refugee, family reunification immigrant, business economy class immigrant	IRCC Database **Note**: Refer to Appendix C
World Regions of Origin	Country of Origin variable (FCOB) was used as a proxy to group immigrants according to world region of origin	IRCC Database **Note**: Refer to Appendix D
Landing Cohort	Year of landing variable was used to group immigrants into landing cohorts – those who arrived between 1992-1995, 1996-1999, 2000-2003, 2004-2007 and 2008-2010. Categorisations were arbitrary and based on equal intervals except for the 2008-2010 group.	IRCC Database
Official Language Proficiency	Fluency in at least one of the two official languages (English and French).	IRCC Database
Education	Level of education at the time of landing to Canada	IRCC Database

6.7 APPENDIX G. A DISCUSSION OF ANALYTIC APPROACHES FOR COMPARING MATCHED COHORTS

Note: *The information presented in this Appendix was consulted and co-authored with an independent Statistician, Dr. Sean Ho, Ph.D. (Anchorlytics Consulting).*

In this dissertation, we were interested to compare the risk of developing any chronic condition and multimorbidity across different immigrant populations compared to long-term residents of Ontario. The study design was retrospective, longitudinal, open cohort, with 1:1 matching of immigrants to long-term residents, based on birth year, sex, and rurality index.

The variables of principal interest in this dissertation may be summarised as follows:

- Outcomes:
    - Occurrence of chronic conditions (incidence of at least 1 of the 9 available chronic health conditions)
    - Multimorbidity (two or more (2+) and three or more (3+) co-occurring chronic conditions)
- Predictor: immigrant status (binary) stratified by immigrant category (refugee, family, economic)
- Matching criteria: birth year, sex, Rurality Index of Ontario score (RIO) > 45 (yes/no)
- Covariates: world region of origin (nominal), neighbourhood income level (ordinal)

Causes of chronic disease and multimorbidity are complex and multifaceted. The "gold standard" of randomised controlled trials was not feasible for this dissertation, and indeed construction of a reasonable ethical framework in which to conduct such studies would be challenging.

The research objectives more usefully serve the wider community by extending beyond a purely descriptive summary of chronic conditions and multimorbidity among immigrants compared to long-term residents, to assess whether immigrants have greater risk of developing a chronic condition or multimorbidity, and what individual-level and social-level factors may be contributing to that difference, to inform public health programs and policy development. This motivates an analysis which controls for the effects of well-known predictors of chronic health conditions and multimorbidity.

Use of matching in a cohort study

The reasons for matching at the design stage of this study were twofold: a) for balancing purposes to ensure there is an adequate number of immigrants and long-term residents across different strata of socio-demographic variables and b) to establish a more defined start point of observation when comparing immigrants to long-term residents in an open cohort.

Balancing

Balancing is particularly important, since a severe imbalance across covariates in data may lead to numerical instability in the estimation of regression coefficients (Cummings et al., 2003). This in turn can lead to large bootstrapped standard errors of estimates (Rubin, 1978; Gelman & Hill,

2007). This is often the case with retrospective cohort comparison studies where one cohort is significantly smaller than the other, such as in the case of our study comparing immigrant populations from our data source of interest (the Immigrant, Refugees and Citizenship Canada Permanent Residents Dataset) to long-term residents of Ontario (identified from the Registered Persons Database). In such situations, either subsampling (if data are relatively abundant) or oversampling (if not) are useful techniques. In this dissertation, we subsampled our long-term resident cohort from the RPDB and matched to our immigrant cohort. If the underlying hypothesised processes are the same, a balanced design is not inherently more "correct" than an unbalanced design; the purpose of balancing is for numerical stability in estimation given limited data (Rubin, 1978; Gelman & Hill, 2007).

Matching in our study ensured that we had an adequate representation of immigrants and long-term residents across different sociodemographic factors. For example, the distribution of immigrants in our study, by age, indicated that immigrants are typically younger (below 50 years of age) and more concentrated in younger age categories (e.g., 30 to 40 years of age). Matching, therefore, ensured we have enough long-term residents across different age categories and by sex in comparison to our immigrant cohort. Consequently, the same rationale was extended to our use of the RIO score. We hypothesized that most immigrants settle in larger urban/metropolis regions across Ontario, based on observations reported in prior studies that have used linked immigration data (IIRC) with ICES data holdings (Creatore, 2013). Since urban/rural disparities have been described as predictors of access to health services (Lucas et al., 2018) and consequently health outcomes (given our reliance on the use of administrative health data), we matched by RIO>45 (yes/no) to ensure that long-term residents are selected and matched to immigrants in similar geographic settings.

Defined starting point of observation period

Matching also ensured a more defined measurement of observation period between immigrants and long-term residents. The open-cohort design enabled immigrants who arrived in Canada, at different points in time (from 1992 to 2010), to enter the study and followed forward. This introduced a complexity when attempting to compare immigrants to long-term residents over time. Matching enabled us to ascertain a more defined baseline (start date) by identifying immigrants who entered the study disease-free, three years following landing in Canada, at which point they were matched to a long-term resident who was also disease-free and followed forward until they either developed the outcome or were censored due to loss of follow up, death or end of the study period. To assess whether censoring was evenly distributed across immigrants and long-term residents, we examined and compared the proportion of immigrants and long-term residents who were censored and further by reasons such as death to investigate any potential bias that may arise in our estimates and found no significant discrepancies in the proportion of censored individuals across the two cohorts.

<u>Choice of 1:1 Matching without replacement</u>

In our study we selected a 1:1 matching *without* replacement. Although different approaches can be used (e.g., matching with replacement and/or ratio matching (1: n) where the number of controls is larger than cases), our selection of 1:1 matching without replacement increased precision and reduced variance (Stuart & Rubin, 2007). Matching *with* replacement has several drawbacks that

were taken into consideration when designing this study. Several limitations of matching *with* replacement include: only a few unique control units may be selected as matches, inference is more complicated, there is a need to account for multiple appearances of controls with weights, reduced precision (i.e. the number of times each control is matched requires monitoring and is reflected in the estimated precision of estimated causal effects as well as increased variance of estimates, since fewer controls are used in the matching process (Stuart & Rubin, 2007; Dehejia & Wahba, 2002).

Although a 1: n ratio matching may reduce variance in estimates by increasing the total sample size of with greater number of controls included, there is a trade-off by introducing a bias when selecting multiple controls (Stuart & Rubin, 2007). This bias will generally increase with the second, third or fourth match since they are further away from the case than the first match (Stuart & Rubin, 2007). Initially, we intended to include a 1:4 matching of immigrants and long-term residents to maximize our sample size and reduce variance. However, in doing so, we observed a dose-response bias. Using this approach, we observed that the risk of developing a condition increased proportionally among the second, third and fourth long-term resident matches, respectively. More generally speaking, in the second/third and fourth round of matching, most of the eligible long-term Ontario residents were the ones who were not matched to an immigrant in later years since they developed a chronic condition, were loss to follow up or died which consequently led to a proportionally increasing Hazard Ratio when comparing the first, second, third, and fourth matches to the immigrant cohort.

Models

In our study, we proceeded with a Cox Proportional Hazard modelling approach in all our multivariate regression analyses. For a binary outcome measured over time (e.g., the occurrence of chronic health condition or multimorbidity which were outcomes used in this dissertation), some commonly used categories of classification models include Cox Proportional Hazard regression, random forests, and neural nets (Collet, 2015). Of these, by far the most common category is Cox Proportional Hazard regression when the research objective is explanatory rather than predictive, all of which were explanatory in this dissertation. Although advancements have been made in numerical methods for local interpretation of some of the more non-parametric methods, regression is still the easiest to interpret (Collet, 2015).

Analytic approaches for comparing matched cohorts

Matched-paired analysis

A related but distinct approach is matched or paired analysis. Each observation in the target group is matched to one or more observations in the comparison group, according to specified criteria. In a retrospective study, this means subsampling of the larger comparison group, as in balancing. However, the essential distinction of paired analysis is not the sampling strategy but the unit of analysis — examining pairwise differences (or within-cluster variation) rather than differences between the two groups as distinct populations. Paired analysis is a subset of repeated-measures analysis, which in turn can be expressed as a subset of multilevel modelling (Gelman & Hill, 2007).

We did not conduct a matched-paired analysis and proceeded with regression modelling with covariates. The criteria used for matching are typically demographic variables, but the purpose is no

different from covariates in a multiple regression model — to control for the effects of confounding variables to isolate the effect of interest. Subsampling via matching without either a pairwise analysis or inclusion of the matching criteria as covariates in multiple regression would not achieve the goal of controlling for the effect of covariates (Rubin 1978; Gerlman & Hill, 2007).

Given the complexity of risk factors that might contribute to the development chronic health conditions and multimorbidity, an essential concern is that appropriate variables are controlled for, regardless of whether they are controlled via matching and paired analysis or by inclusion as covariates in a multiple regression analysis (Cummings et al., 2003). Within the context of migrant health, factors such as age, sex and socio-economic factors (e.g. income), lifestyle factors (e.g. tobacco/alcohol use, exercise/activity, diet, obesity, blood pressure, cholesterol, etc. which were not available in our data) combined with migrant-characteristics such as type of immigrant and ethnicity (or country/world regions of origin as a proxy) are known as predictors of chronic disease development, as discussed in the introduction chapter of this dissertation. If one group has a higher occurrence of a chronic health condition than the other, it would be constructive to examine whether that is due to a difference in these known risk factors, or in a different causal pathway (Collet, 2015).

Pairwise analysis has a limitation due to a combinatorial explosion as the number of matching criteria increase. The original sample might have one immigrant for every 10,000 long-term residents, but it may not be feasible to find a long-term resident that matches the immigrant on not only age, sex, and rurality, but also every other factor noted above. This motivates an approach which primarily relies on multiple regression to control for the effects of known covariates, but still incorporates subsampling on select demographic variables — not for the purpose of completely controlling for their effect, but for the purpose of numerical stability in estimation of regression coefficients. The multiple regression analysis is then also free to control for any residual effects of the matching criteria (Collet, 2015).

There are advantages to comparing matched groups while controlling for matching variables, as opposed to examining 1:1 pairwise difference. One advantage is in statistical power: if there are large number of immigrants (and matched long-term residents) with similar values on the matching factors, they yield greater precision in the estimates of regression effects. Another advantage is that sometimes matching can induce bias in the estimated effects, which can be ameliorated in the non-paired analysis by controlling for the matching factors.

In our multivariate regression analyses, we adjusted for age and sex, which were variables used to match immigrants and long-term Ontario residents in the study design. The literature states that while a matched analysis is not needed when analyzing matched cohort data, adjustment for the matching variables is recommended at the analysis stage (Cummings et al., 2003). Ignoring the matching variables in a cohort study can leave bias when additional confounders are present, even after adjusting for the additional confounders. This bias is avoided by adjusting for the matching variables (Sjölander & Greenland, 2013).

Similar approaches have been used in recent studies using a logistic/proportional-hazards regression approach by incorporating covariates based on theory, with matching subsampling used for the purpose of balancing and numerical stability (Darkins et al, 2015; Short et al., 2011; Liao et al., 2014; Turner et a., 2016).

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6.8 APPENDIX H. MODEL BUILDING PROTOCOL AND METHODOLOGY FOR COX PROPORTIONAL HAZARD MODELS

Several steps were taken to derive the final multivariate Cox Proportional Hazard models. This comprised of identifying which covariates to include in the multivariate models, testing the Cox Proportional Hazard model assumptions and the AIC criterion for final model selection.

We used product-limit estimator methods, Kaplan-Meir survival curves and log rank tests to assess which covariates to include in the multivariate analysis.

As discussed in Appendix G, we fist explored the data to assess whether censoring was evenly distributed across immigrant and long-term Ontario residents. Our data contained only right-censored data where some individuals observed the occurrence of the event and for others, they were censored due to loss of follow-up, death, or end of the observation period. We assumed non-informative censoring (i.e., observing or failing to observe the event is not related to the probability of the event occurring). To assess this assumption, we examined and compared the proportion of immigrants and long-term residents who were censored and further by death to assess if the pattern of censoring is random, which if it is not, can bias estimates. We further examined the proportion of people who were censored by immigrant category, world regions of origin, age and sex and found no significant discrepancies in the proportion of censored individuals.

To test the Cox Proportional Hazard model assumptions, we first examined key assumptions that must be upheld for Cox Proportional Hazard modelling:

1) Hazard Ratio is constant over time.

2) The relationship between the log hazard and a continuous covariate variable is linear.

Linearity assumption

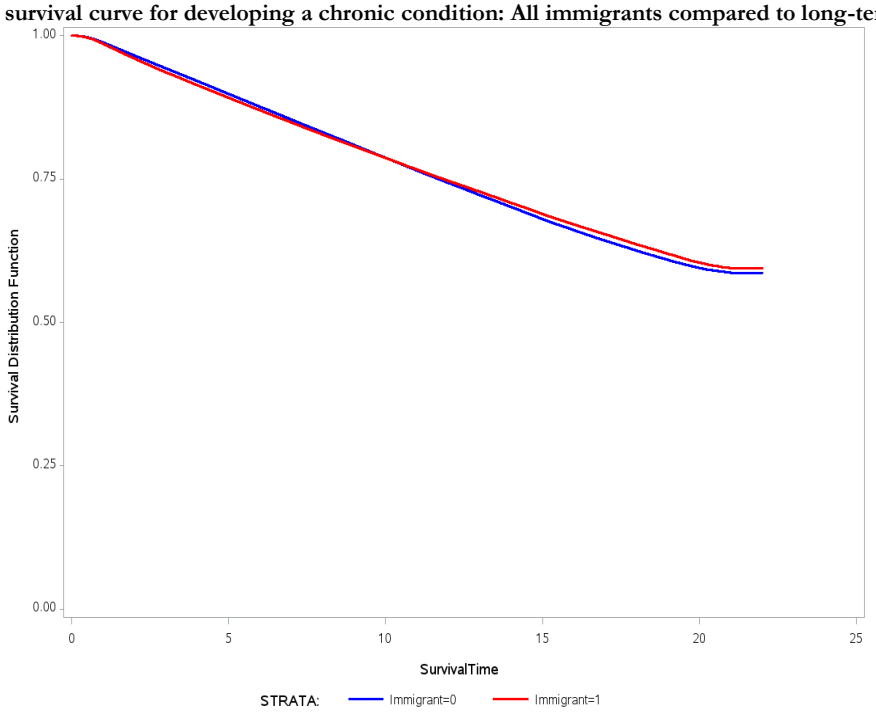
We did not include any continuous variables in our multivariate models. Originally, age was derived as a continuous variable, however, we categorized this variable into age groups. When we first examined the distribution of immigrants by age, the data indicated that immigrants are typically younger (below 50 years of age) and more concentrated in younger age categories (e.g., 30 to 40 years of age). This is likely due to the inclusion criteria of our study that specified immigrants must be disease free from all the nine ICES-derived disease cohorts, three years following landing, and with existing immigration medical screening protocols, immigrants typically arrive younger and healthier. Given that our outcome measures examined chronic disease development and multimorbidity, we were interested in the main effect of immigration and adjusted for the effect of age across the lifespan (young, middle-aged, old), and not as a continuous (integer) value.

Proportional Hazards assumption

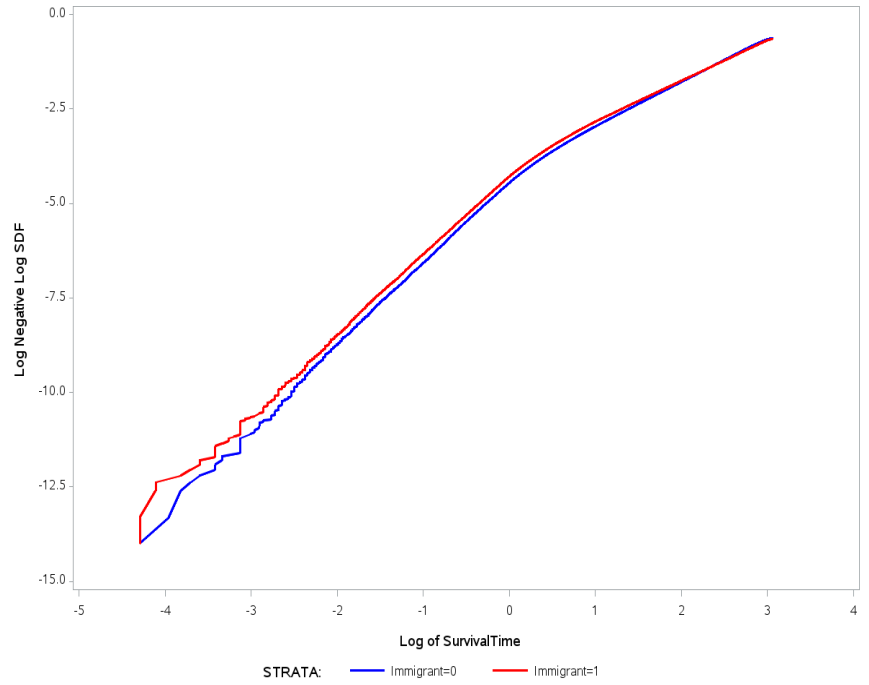
We tested the proportionality hazards assumption by plotting the log-negative-log of the Kaplan-Meir survival curves versus the log of survival time. If the proportionality assumption is upheld (and the hazard ratios are constant) then the plot would show parallel lines.

We first examined the Kaplan-Meir curve for developing any chronic condition by our immigrant (yes/no) variable compared to long-term residents. We suspected a potential time interaction with immigrant status (risk changing over time). We stratified by immigrant category to examine the individual Kaplan-Meir curves for refugees compared to their long-term resident matches, families and by economic class immigrants with their respective matches. We then plotted the log-negative-log of the Kaplan-Meir curves versus the log of the survival time for all immigrants compared to long-term residents to see if the plots show parallel lines, but there appeared to be an overlap. When we examined the stratified curves by immigrant category, the plots were more parallel versus when they were combined in one immigrant group for refugees and economic class immigrants but no difference by family immigrants compared to their long-term resident matches.

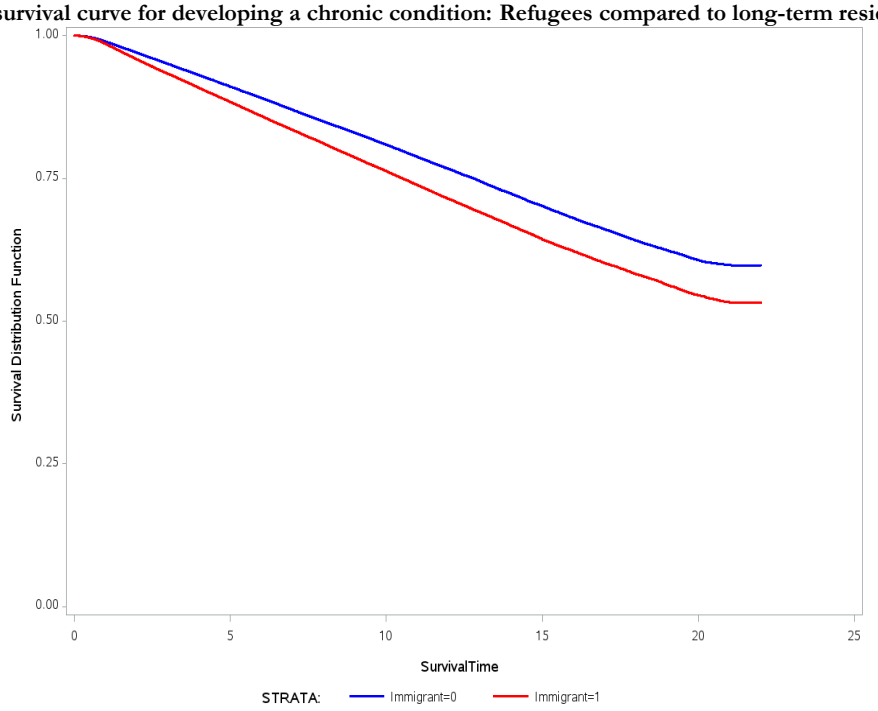
Kaplan-Meir survival curve for developing a chronic condition: All immigrants compared to long-term residents



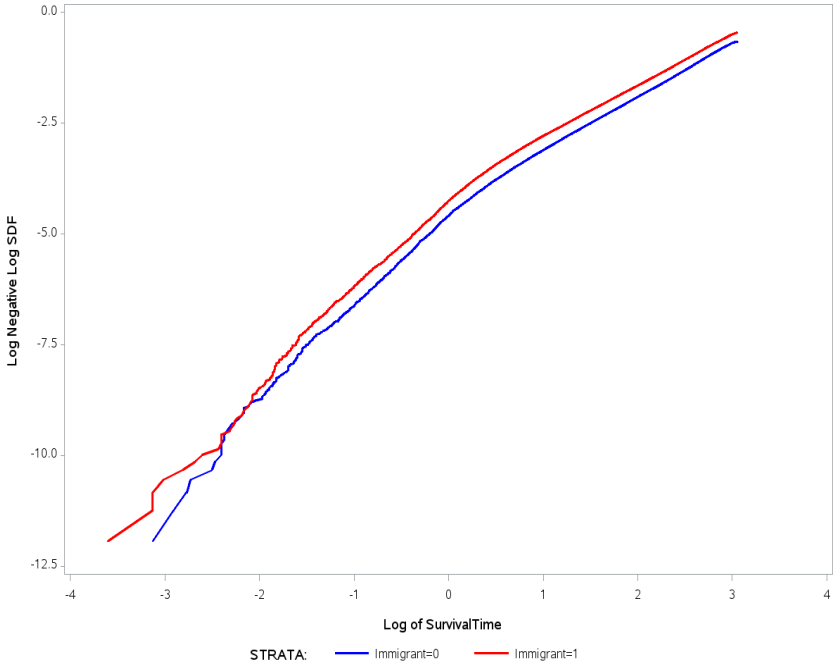
Log-negative-log of the Kaplan-Meir curves versus the log of the survival time: All immigrants compared to long-term residents



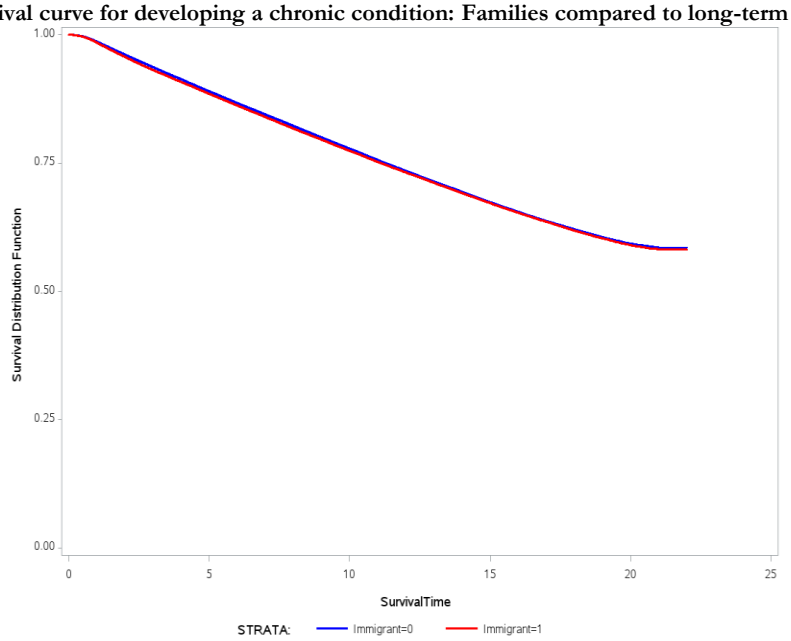
Kaplan-Meir survival curve for developing a chronic condition: Refugees compared to long-term resident matches



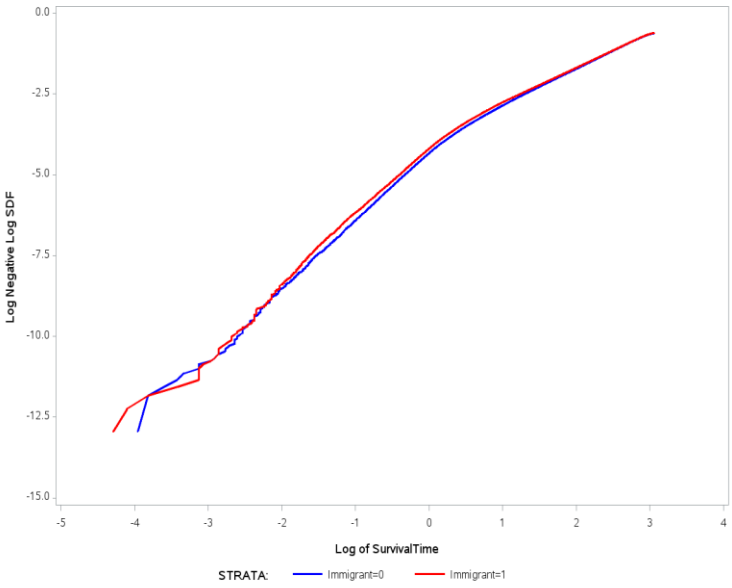
Log-negative-log of the Kaplan-Meir curves versus the log of the survival time: Refugees compared to long-term resident matches



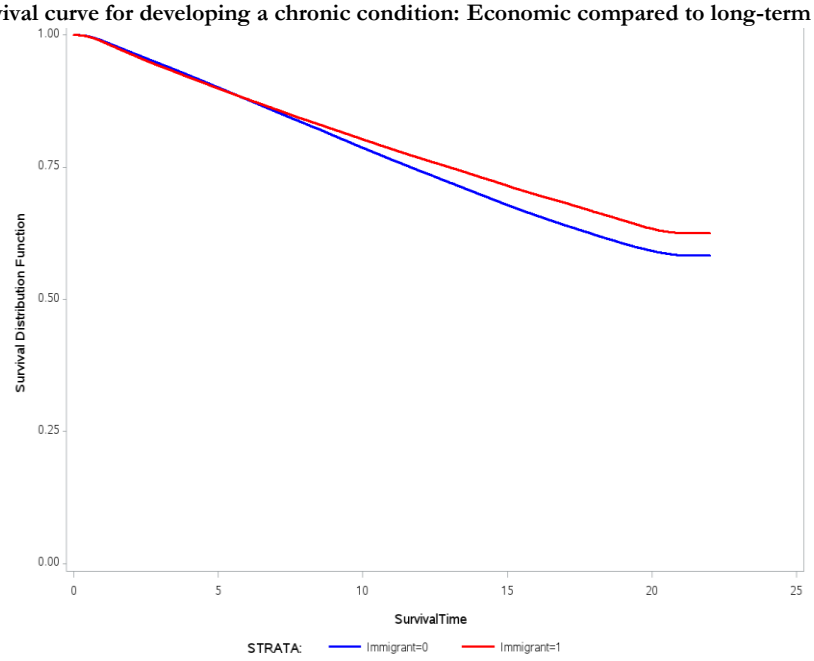
Kaplan-Meir survival curve for developing a chronic condition: Families compared to long-term resident matches



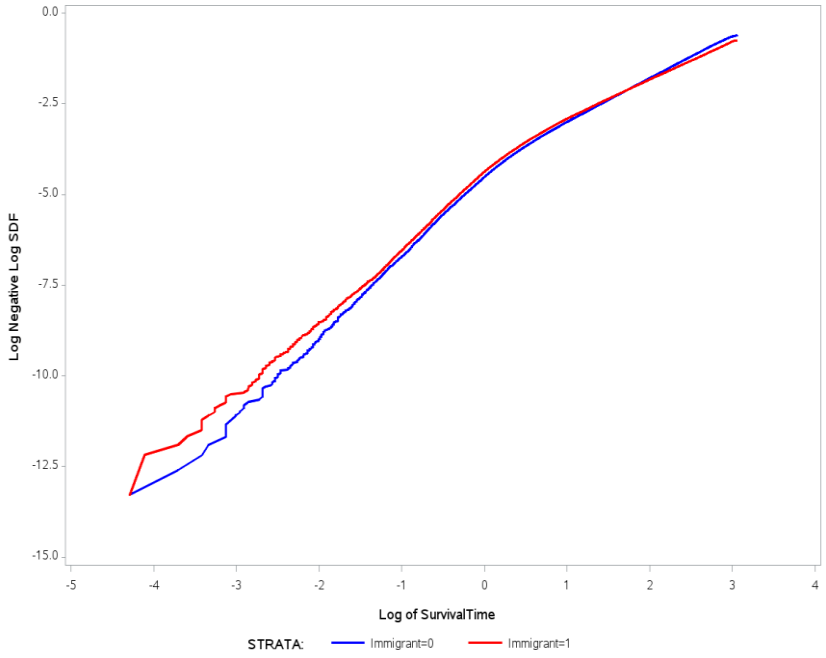
Log-negative-log of the Kaplan-Meir curves versus the log of the survival time: Families compared to long-term resident matches



Kaplan-Meir survival curve for developing a chronic condition: Economic compared to long-term resident matches



Log-negative-log of the Kaplan-Meir curves versus the log of the survival time: Economic compared to long-term resident matches



Based on the potential time*immigrant interaction, we calculated the relative risk of developing a chronic condition for all immigrants compared to long-term residents and compared them to the Kaplan-Meir curves and crude Hazard Ratios. We did some testing to calculate the relative risk by different follow-up times and found the relative risks change. Based on the changing relative risk and Kaplan-Meir curves for immigrants and long-term residents, we found that immigrants have the same risk or are slightly unhealthier at the beginning, but after 5 to 10 years their risk changes. This was not consistent for individual immigrant categories. We attempted to examine a time*immigrant interaction in the Cox Model, but the data was too large to support this analysis. Based on our findings we were able to conclude there was a time interaction with the "All" immigrant variable. As a result, our analytic approach was to run separate Cox Proportional Hazard models that were stratified by immigrant categories.

We also examined the Kaplan-Meir curves for each individual chronic condition. The Kaplan-Meir curves showed either the same survival for some conditions or an apparent difference. Apart from hypertension and diabetes (where immigrants did worse), immigrants had the same or better survival compared to long-term Ontario residents.

Unadjusted Hazard Ratios were first calculated by immigrant status, and by immigrant category. Cox proportional hazard models were built by immigrant status, age, and sex (in various combinations) to look for changes in the effect size of age, sex, or both. Stratified models were also built by immigrant category. We found no major changes in the effect size of immigrant status by age and sex (with a slight exception in the older age category) when we ran the stratified models. Per the specifications outlined in Appendix G, we adjusted for age and sex in all our multivariate models. Variables such as neighborhood income quintile, world regions of origin, as well as interaction terms of immigrant status*world regions of origin or immigrant status*landing period were included both individually and together, where applicable, and compared. We examined the Hazard Ratios, p values 95% Confidence Intervals and the AIC scores when comparing and selecting the final models.

For all models, we used complete case analysis and excluded anyone with missing information. We had complete data for immigrants and long-term residents based on the matching criteria. Missing data was observed for neighborhood-level income quintiles and certain migrant characteristics, such as world regions of origin (i.e., unknown category or actual missing). The total number of missing data corresponded to <1% of the eligible study population. We treated unknown world regions of origin as missing data to keep it consistent with our approach to conduct complete case analyses. We conducted a descriptive, sensitivity analysis for participants with missing information to those with complete data, based on age and sex. This was completed to identify potential differences in the socio-demographic profile of our eligible study population and to avoid potential biases when conducting analyses and found no statistically significant differences between the two groups.

6.9 APPENDIX I. SEX-STRATIFIED ANALYSES

Sex-stratified analyses were conducted to compare rates of chronic disease development and multimorbidity between immigrants and long-term residents. In this appendix, we present sex-stratified results for select analyses from chapters 2 and 3. All models presented below were further stratified by immigrant visa categories when comparing the risk of immigrants to long-term residents.

Risk of developing a chronic condition – Sex-stratified Multivariate Cox Proportional Hazard Models adjusted by immigrant status (yes/no), age categories and neighborhood income quintiles.

Refugees vs. long-term residents - Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	1.18	1.16	1.21
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	2.05	2.00	2.10
50+	<.0001	4.46	4.34	4.60
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.23	1.19	1.28
Q2	<.0001	1.18	1.13	1.22
Q3	<.0001	1.11	1.07	1.15
Q4	<.0001	1.08	1.04	1.13
Q5 (reference)	---	---	---	---

Refugees vs. long-term residents – Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	1.20	1.17	1.23
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	1.97	1.92	2.03
50+	<.0001	4.10	3.97	4.24
NEIGHBORHOOD INCOME QUINTILES				

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Q1 (lowest income)	<.0001	1.33	1.28	1.38
Q2	<.0001	1.27	1.22	1.32
Q3	<.0001	1.18	1.13	1.24
Q4	<.0001	1.10	1.05	1.15
Q5 (reference)	---	---	---	---

Families vs. long-term residents – Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	0.0045	0.98	0.97	0.99
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	1.85	1.82	1.89
50+	<.0001	5.28	5.18	5.37
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.28	1.26	1.31
Q2	<.0001	1.21	1.18	1.24
Q3	<.0001	1.17	1.14	1.20
Q4	<.0001	1.10	1.07	1.13
Q5 (reference)	---	---	---	---

Families vs. long-term residents – Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	0.95	0.94	0.96
AGE CATEGORIES				
18–29 (reference)	---	---	---	---

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
30–49	<.0001	1.75	1.72	1.78
50+	<.0001	5.09	5.02	5.17
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.43	1.40	1.45
Q2	<.0001	1.29	1.27	1.32
Q3	<.0001	1.22	1.19	1.24
Q4	<.0001	1.12	1.10	1.14
Q5 (reference)	---	---	---	---

Economic vs. long-term residents – Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	0.88	0.87	0.88
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	2.12	2.07	2.16
50+	<.0001	4.24	4.14	4.33
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.26	1.24	1.28
Q2	<.0001	1.22	1.20	1.24
Q3	<.0001	1.18	1.15	1.20
Q4	<.0001	1.12	1.10	1.14
Q5 (reference)	---	---	---	---

Economic vs. long-term residents – Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	0.89	0.88	0.90
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	1.93	1.89	1.97
50+	<.0001	3.69	3.61	3.77
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.38	1.36	1.41
Q2	<.0001	1.27	1.24	1.29
Q3	<.0001	1.20	1.18	1.22
Q4	<.0001	1.14	1.12	1.16
Q5 (reference)	---	---	---	---

<u>Risk of developing a chronic condition – Sex-Stratified multivariate analyses</u> for Immigrants compared to long-term residents by World Region of Origin. The Hazard Ratios presented were obtained from the world region of origin and immigrant interaction terms used in the multivariate models that were adjusted by immigrant status (yes/no), age categories, neighborhood income quintiles.

Refugees vs. long-term residents – Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Caribbean	0.270	1.11	0.92	1.34
East Asia & the Pacific	0.338	0.97	0.91	1.04
Eastern Europe & Central Asia	0.001	0.93	0.87	0.89
Latin America	<.0001	0.85	0.80	0.91
North Africa & the Middle East	0.023	1.06	1.01	1.11
South Asia	<.0001	1.78	1.72	1.84
Sub-Saharan Africa	<.0001	1.16	1.10	1.21
Western Europe & the US	0.389	1.21	0.90	1.64

Refugees vs. long-term residents – Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Caribbean	0.002	1.35	1.12	1.62
East Asia & the Pacific	0.653	0.98	0.91	1.06
Eastern Europe & Central Asia	0.016	0.94	0.90	0.99
Latin America	0.430	1.03	0.96	1.11
North Africa & the Middle East	0.0001	1.12	1.06	1.20
South Asia	<.0001	1.68	1.60	1.74
Sub-Saharan Africa	<.0001	1.28	1.21	1.34
Western Europe & the US	0.389	1.01	0.74	1.37

Families vs. long-term residents – Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Caribbean	<.0001	1.12	1.08	1.17
East Asia & the Pacific	<.0001	0.82	0.80	0.84
Eastern Europe & Central Asia	<.0001	0.82	0.78	0.86
Latin America	0.711	1.01	0.96	1.06
North Africa & the Middle East	<.0001	0.84	0.79	0.89
South Asia	<.0001	1.32	1.29	1.35
Sub-Saharan Africa	0.011	1.09	1.02	1.17
Western Europe & the US	0.952	0.74	0.71	0.78

Families vs. long-term residents – Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Caribbean	<.0001	1.36	1.31	1.41
East Asia & the Pacific	<.0001	0.75	0.74	0.77
Eastern Europe & Central Asia	<.0001	0.82	0.79	0.84
Latin America	0.060	1.04	1.00	1.08
North Africa & the Middle East	0.0001	0.91	0.87	0.96
South Asia	<.0001	1.27	1.24	1.30
Sub-Saharan Africa	0.0009	1.10	1.04	1.16

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Western Europe & the US	0.016	0.67	0.64	0.70

Economic vs. long-term residents – Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Caribbean	<.0001	1.14	1.07	1.22
East Asia & the Pacific	<.0001	0.72	0.70	0.73
Eastern Europe & Central Asia	<.0001	0.84	0.81	0.86
Latin America	<.0001	0.79	0.74	0.84
North Africa & the Middle East	<.0001	0.80	0.77	0.83
South Asia	<.0001	1.22	1.20	1.24
Sub-Saharan Africa	0.057	0.95	0.89	1.00
Western Europe & the US	0.832	0.62	0.59	0.65

Economic vs. long-term residents – Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Caribbean	<.0001	1.41	1.34	1.48
East Asia & the Pacific	<.0001	0.80	0.79	0.82
Eastern Europe & Central Asia	<.0001	0.76	0.74	0.79
Latin America	<.0001	0.86	0.81	0.92
North Africa & the Middle East	<.0001	0.79	0.76	0.83
South Asia	<.0001	1.25	1.22	1.28
Sub-Saharan Africa	0.038	1.07	1.00	1.14
Western Europe & the US	0.038	0.61	0.58	0.64

Risk of developing multimorbidity (two or more co-occurring chronic conditions)– Sex-stratified Multivariate Cox Proportional Hazard Models adjusted by immigrant status (yes/no), age categories and neighborhood income quintiles.

Refugees vs. long-term residents - Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	1.23	1.19	1.28
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	2.89	2.74	3.05
50+	<.0001	8.27	7.80	8.77
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.37	1.28	1.46
Q2	<.0001	1.24	1.15	1.33
Q3	0.0001	1.15	1.07	1.24
Q4	0.0009	1.14	1.05	1.22
Q5 (reference)	---	---	---	---

Refugees vs. long-term residents – Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	1.26	1.20	1.32
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	2.62	2.46	2.80
50+	<.0001	7.26	6.77	7.78
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.47	1.35	1.59
Q2	<.0001	1.29	1.18	1.40
Q3	<.0001	1.24	1.14	1.35

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Q4	0.2877	1.05	0.96	1.15
Q5 (reference)	---	---	---	---

Families vs. long-term residents – Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	0.94	0.92	0.96
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	2.56	2.46	2.67
50+	<.0001	11.6	11.2	12.0
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.42	1.37	1.48
Q2	<.0001	1.30	1.25	1.35
Q3	<.0001	1.21	1.16	1.26
Q4	<.0001	1.11	1.07	1.16
Q5 (reference)	---	---	---	---

Families vs. long-term residents –Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	0.93	0.92	0.95
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	2.52	2.44	2.61
50+	<.0001	10.4	10.1	10.8
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.69	1.64	1.75

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Q2	<.0001	1.44	1.39	1.50
Q3	<.0001	1.34	1.29	1.39
Q4	<.0001	1.18	1.13	1.22
Q5 (reference)	---	---	---	---

Economic vs. long-term residents – Males

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	0.82	0.81	0.84
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	2.88	2.74	3.03
50+	<.0001	7.96	7.57	8.37
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.47	1.42	1.52
Q2	<.0001	1.37	1.33	1.42
Q3	<.0001	1.29	1.24	1.33
Q4	<.0001	1.18	1.14	1.22
Q5 (reference)	---	---	---	---

Economic vs. long-term residents – Females

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
Immigrant (yes)	<.0001	0.85	0.83	0.87
AGE CATEGORIES				
18–29 (reference)	---	---	---	---
30–49	<.0001	2.52	2.40	2.64

	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Intervals	
50+	<.0001	6.02	5.74	6.33
NEIGHBORHOOD INCOME QUINTILES				
Q1 (lowest income)	<.0001	1.68	1.62	1.75
Q2	<.0001	1.48	1.42	1.54
Q3	<.0001	1.34	1.28	1.39
Q4	<.0001	1.21	1.16	1.26
Q5 (reference)	---	---	---	---

6.10 APPENDIX J. MULTIVARIATE COX PROPORTIONAL HAZARD MODEL OUTPUTS WITH INTERACTION TERMS

The complete multivariate Cox proportional Hazard model outputs using the world regions of origin interaction terms for chapters 2 and 3 are provided for each model stratified by immigrant visa category.

In chapter 2, we examined the risk of developing any chronic condition for immigrants compared to long-term residents. We built three stratified models, by immigrant visa category, and adjusted for age, sex, and neighborhood income quintiles. We then included an interaction term for immigrant status*world region of origin to estimate the risk for immigrants, by different world regions of origin, when compared to long-term residents, as depicted in the following formula:

Chronic Condition Outcome= Immigrant (yes/no) + Age Category + Sex + Neighborhood level income +

Immigrant*World Region of Origin

Chapter 2 Model Outputs

Refugees vs. long-term residents

N= 151, 053 Refugees N= 151, 053 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	0.10370	0.10972	0.3446	.	.	.
Age Categories						
30-49	0.72127	0.00970	<.0001	2.06	2.02	2.10
50+	1.49225	0.01126	<.0001	4.45	4.35	4.55
Sex (female)	-0.06103	0.00730	<.0001	0.94	0.93	0.95
Neighborhood Income Quintiles						
Q1 (lowest income)	0.21011	0.01363	<.0001	1.23	1.20	1.27
Q2	0.18063	0.01413	<.0001	1.20	1.16	1.23
Q3	0.12175	0.01473	<.0001	1.13	1.10	1.16
Q4	0.07848	0.01530	<.0001	1.08	1.00	1.12
World Regions of Origin						
Caribbean	-0.12868	0.09431	0.1725	.	.	.
East Asia & the Pacific	-0.01380	0.08215	0.8666	.	.	.
Eastern Europe & Central Asia	0.08105	0.08087	0.3162	.	.	.
Latin America	-0.01178	0.08199	0.8857	.	.	.
North Africa & Middle East	0.03520	0.08126	0.6649	.	.	.

N= 151, 053 Refugees N= 151, 053 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
South Asia	0.01260	0.08076	0.8760	.	.	.
Sub-Saharan Africa	0.02412	0.08111	0.7662	.	.	.
Western Europe & US	0.24046	0.23246	0.3009	.	.	.
Interaction Term						
Immigrant*Caribbean	0.10033	0.12846	0.0023	1.23	1.06	1.40
Immigrant*East Asia & the Pacific	-0.13081	0.11267	0.2962	0.97	0.92	1.02
Immigrant*Eastern Europe & Central Asia	-0.16924	0.11083	<.0001	0.94	0.91	0.97
Immigrant*Latin America	-0.17687	0.11249	0.0036	0.93	0.88	0.98
Immigrant*North Africa & Middle East	-0.02397	0.11132	<.0001	1.08	1.03	1.13
Immigrant*South Asia	0.44528	0.11049	<.0001	1.73	1.68	1.78
Immigrant*sub-Saharan Africa	0.08909	0.11109	<.0001	1.21	1.17	1.25
Immigrant*Western Europe & US	-0.04872	0.32752	0.8586	1.11	0.84	1.38

Families vs. long-term residents

N=416,317 Families N=416,317 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	-0.34630	0.01686	<.0001	.	.	.
Age Categories						
30-49	0.61063	0.00602	<.0001	1.84	1.82	1.86
50+	1.66379	0.00581	<.0001	5.28	5.22	5.34
Sex (female)	-0.10608	0.00444	<.0001	0.89	0.88	0.90
Neighborhood Income Quintiles						
Q1 (lowest income)	0.26308	0.00741	<.0001	1.30	1.28	1.32
Q2	0.19799	0.00755	<.0001	1.22	1.20	1.24
Q3	0.15050	0.00771	<.0001	1.16	1.14	1.18
Q4	0.08557	0.00791	<.0001	1.09	1.07	1.11
World Regions of Origin						
Caribbean	0.02496	0.01536	0.1041	.	.	.
East Asia & the Pacific	0.10615	0.01233	<.0001	.	.	.
Eastern Europe & Central Asia	0.07065	0.01472	<.0001	.	.	.
Latin America	0.01435	0.01567	0.3599	.	.	.
North Africa & Middle East	-0.01823	0.01736	0.2938	.	.	.

N=416,317 Families N=416,317 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
South Asia	-0.0001477	0.01272	0.9907	.	.	.
Sub-Saharan Africa	-0.00512	0.01948	0.7926	.	.	.
Western Europe & US	0.57037	0.16260	0.0005	.	.	.
Interaction Term						
Immigrant*Caribbean	0.54959	0.02215	<.0001	1.23	1.19	1.27
Immigrant*East Asia & the Pacific	0.09620	0.01871	<.0001	0.78	0.77	0.79
Immigrant*Eastern Europe & Central Asia	0.14418	0.02198	<.0001	0.82	0.80	0.84
Immigrant*Latin America	0.37102	0.02288	<.0001	1.03	0.99	1.07
Immigrant*North Africa & Middle East	0.22138	0.02562	<.0001	0.88	0.85	0.91
Immigrant*South Asia	0.60112	0.01883	<.0001	1.29	1.27	1.31
Immigrant*sub-Saharan Africa	0.43973	0.02773	<.0001	1.10	1.05	1.15
Immigrant*Western Europe & US	-0.11694	0.24715	0.6361	0.71	0.68	0.74

Economic vs. long-term residents

N=585,539 Economic N=585,539 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	-0.48865	0.01770	<.0001	.	.	.
Age Categories						
30-49	0.70770	0.00726	<.0001	2.02	2.00	2.06
50+	1.38805	0.00780	<.0001	4.01	3.95	4.07
Sex (female)	-0.08664	0.00393	<.0001	0.92	0.91	0.93
Neighborhood Income Quintiles						
Q1 (lowest income)	0.23357	0.00641	<.0001	1.26	1.25	1.28
Q2	0.18696	0.00661	<.0001	1.21	1.19	1.22
Q3	0.14774	0.00673	<.0001	1.16	1.14	1.18
Q4	0.09842	0.00684	<.0001	1.10	1.09	1.12
World Regions of Origin						
Caribbean	0.0004856	0.01899	0.9796	.	.	.
East Asia & the Pacific	-0.02688	0.01186	0.0235	.	.	.
Eastern Europe & Central Asia	-0.03714	0.01295	0.0041	.	.	.
Latin America	-0.06633	0.01829	0.0003	.	.	.
North Africa & Middle East	-0.08075	0.01408	<.0001	.	.	.

N=585,539 Economic N=585,539 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
South Asia	-0.12153	0.01246	<.0001	.	.	.
Sub-Saharan Africa	-0.03609	0.01897	0.0572	.	.	.
Western Europe & US	0.39031	0.20442	0.0562	.	.	.
Interaction Term						
Immigrant*Caribbean	0.74706	0.02722	<.0001	1.30	1.25	1.35
Immigrant*East Asia & the Pacific	0.21727	0.01888	<.0001	0.76	0.75	0.77
Immigrant*Eastern Europe & Central Asia	0.26799	0.02033	<.0001	0.80	0.79	0.81
Immigrant*Latin America	0.29328	0.02783	<.0001	0.82	0.78	0.86
Immigrant*North Africa & Middle East	0.26108	0.02198	<.0001	0.80	0.78	0.82
Immigrant*South Asia	0.69523	0.01939	<.0001	1.23	1.21	1.25
Immigrant*sub-Saharan Africa	0.48629	0.02816	<.0001	1.00	0.96	1.04
Immigrant*Western Europe & US	-0.03227	0.32324	0.9205	0.61	0.59	0.63

In chapter 3, we examined multimorbidity outcomes (2+ and 3+ co-occurring chronic conditions) to estimate the risk for immigrants compared to long-term residents. We build three stratified models by immigrant visa category adjusting for age, sex, and neighborhood income quintiles, and included an interaction term for immigrant status*world region of origin to estimate the risk for immigrants across different world regions of origin, when compared to long-term residents:

Multimorbidity Outcomes= Immigrant (yes/no) + Age Category + Sex + Neighborhood level income +

Immigrant*World Region of Origin

Chapter 3 Model Outputs

Refugees vs. long-term residents – 2+ multimorbidity

N= 151, 053 Refugees N= 151, 053 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	0.53831	0.22241	0.0155	.	.	.
Age Categories						
30-49	1.04761	0.02154	<.0001	2.85	2.73	2.97
50+	2.10286	0.02304	<.0001	8.19	7.83	8.57
Sex (female)	-0.13305	0.01378	<.0001	0.87	0.85	0.89

N= 151, 053 Refugees N= 151, 053 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Neighborhood Income Quintiles						
Q1 (lowest income)	0.29461	0.02645	<.0001	1.34	1.28	1.41
Q2	0.20472	0.02750	<.0001	1.23	1.16	1.30
Q3	0.15641	0.02863	<.0001	1.17	1.11	1.24
Q4	0.08159	0.02997	0.0065	1.08	1.02	1.15
World Regions of Origin						
Caribbean	0.07930	0.20585	0.7000	.	.	.
East Asia & the Pacific	0.25360	0.18052	0.1601	.	.	.
Eastern Europe & Central Asia	0.31470	0.17802	0.0771	.	.	.
Latin America	0.23156	0.18026	0.1989	.	.	.
North Africa & Middle East	0.28114	0.17873	0.1157	.	.	.
South Asia	0.20636	0.17799	0.2463	.	.	.
Sub-Saharan Africa	0.30010	0.17860	0.0929	.	.	.
Western Europe & US	0.25171	0.44494	0.5716	.	.	.
Interaction Term						
Immigrant*Caribbean	-0.33514	0.26299	0.1484	1.23	1.09	1.38
Immigrant*East Asia & the Pacific	-0.66443	0.22844	0.0167	0.88	0.80	0.98
Immigrant*Eastern Europe & Central Asia	-0.68244	0.22431	<.0001	0.87	0.82	0.92
Immigrant*Latin America	-0.73962	0.22817	<.0001	0.82	0.74	0.91
Immigrant*North Africa & Middle East	-0.39307	0.22515	<.0001	1.16	1.08	1.24
Immigrant*South Asia	0.19159	0.22374	<.0001	2.08	1.97	2.18
Immigrant*sub-Saharan Africa	-0.35594	0.22495	<.0001	1.20	1.12	1.29
Immigrant*Western Europe & US	0.26951	0.54724	0.1062	1.71	1.11	2.32

Families vs. long-term residents – 2+ multimorbidity

N=416,317 Families N=416,317 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	-0.34632	0.03238	<.0001	.	.	.
Age Categories						
30-49	0.95989	0.01363	<.0001	2.61	2.54	2.68
50+	2.41341	0.01256	<.0001	11.2	10.9	11.4
Sex (female)	-0.24916	0.00786	<.0001	0.78	0.77	0.79

N=416,317 Families N=416,317 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Neighborhood Income Quintiles						
Q1 (lowest income)	0.39841	0.01339	<.0001	1.49	1.45	1.53
Q2	0.28612	0.01367	<.0001	1.33	1.30	1.37
Q3	0.21211	0.01400	<.0001	1.24	1.20	1.27
Q4	0.11536	0.01448	<.0001	1.12	1.09	1.16
World Regions of Origin						
Caribbean	0.04463	0.02871	0.1200	.	.	.
East Asia & the Pacific	0.19494	0.02286	<.0001	.	.	.
Eastern Europe & Central Asia	0.11126	0.02702	<.0001	.	.	.
Latin America	0.03336	0.02932	0.2552	.	.	.
North Africa & Middle East	0.05320	0.03225	0.0990	.	.	.
South Asia	0.06302	0.02382	0.0082	.	.	.
Sub-Saharan Africa	0.05706	0.03690	0.1220	.	.	.
Western Europe & US	0.71912	0.26808	0.0073	.	.	.
Interaction Term						
Immigrant*Caribbean	0.53714	0.04159	<.0001	1.21	1.15	1.27
Immigrant*East Asia & the Pacific	0.00800	0.03530	0.8208	0.71	0.69	0.73
Immigrant*Eastern Europe & Central Asia	0.06570	0.04110	0.1099	0.76	0.72	0.780
Immigrant*Latin America	0.44901	0.04275	<.0001	1.11	1.05	1.17
Immigrant*North Africa & Middle East	0.19637	0.04810	<.0001	0.86	0.80	0.92
Immigrant*South Asia	0.62820	0.03571	<.0001	1.33	1.29	1.37
Immigrant*sub-Saharan Africa	0.29884	0.05351	<.0001	0.96	0.88	1.04
Immigrant*Western Europe & US	-0.12173	0.40422	0.7633	0.71	0.66	0.76

Economic vs. long-term residents – 2+ multimorbidity

N=585,539 Economic N=585,539 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	-0.62215	0.03541	<.0001	.	.	.
Age Categories						
30-49	0.99738	0.01742	<.0001	2.71	2.62	2.80
50+	1.95917	0.01790	<.0001	7.09	6.85	7.35
Sex (female)	-0.16801	0.00782	<.0001	0.84	0.83	0.86

N=585,539 Economic N=585,539 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Neighborhood Income Quintiles						
Q1 (lowest income)	0.39114	0.01294	<.0001	1.48	1.44	1.52
Q2	0.30955	0.01334	<.0001	1.36	1.33	1.34
Q3	0.23641	0.01365	<.0001	1.27	1.23	1.30
Q4	0.14825	0.01399	<.0001	1.16	1.13	1.19
World Regions of Origin						
Caribbean	-0.02431	0.03575	0.4966	.	.	.
East Asia & the Pacific	-0.02679	0.02217	0.2269	.	.	.
Eastern Europe & Central Asia	-0.08863	0.02450	0.0003	.	.	.
Latin America	-0.10586	0.03534	0.0027	.	.	.
North Africa & Middle East	-0.12668	0.02715	<.0001	.	.	.
South Asia	-0.19386	0.02388	<.0001	.	.	.
Sub-Saharan Africa	-0.01060	0.03592	0.7678	.	.	.
Western Europe & US	0.03367	0.40877	0.9344	.	.	.
Interaction Term						
Immigrant*Caribbean	0.93005	0.05200	<.0001	1.36	1.26	1.46
Immigrant*East Asia & the Pacific	0.19801	0.03776	<.0001	0.65	0.64	0.66
Immigrant*Eastern Europe & Central Asia	0.24269	0.04086	<.0001	0.68	0.66	0.70
Immigrant*Latin America	0.45885	0.05492	<.0001	0.85	0.78	0.92
Immigrant*North Africa & Middle East	0.38331	0.04431	<.0001	0.79	0.75	0.83
Immigrant*South Asia	0.94370	0.03882	<.0001	1.38	1.34	1.42
Immigrant*sub-Saharan Africa	0.48794	0.05581	<.0001	0.87	0.80	0.94
Immigrant*Western Europe & US	0.71373	0.57845	0.2172	0.54	0.50	0.58

Refugees vs. long-term residents – 3+ multimorbidity

N= 151, 053 Refugees N= 151, 053 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	0.49062	0.42182	0.2448	.	.	.
Age Categories						
30-49	1.29509	0.05417	<.0001	3.65	3.28	4.06
50+	2.65824	0.05533	<.0001	14.3	12.8	15.9
Sex (female)	-0.21291	0.02945	<.0001	0.81	0.76	0.86

N= 151, 053 Refugees N= 151, 053 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Neighborhood Income Quintiles						
Q1 (lowest income)	0.41973	0.05666	<.0001	1.52	1.36	1.70
Q2	0.28862	0.05890	<.0001	1.34	1.19	1.50
Q3	0.32833	0.06014	<.0001	1.39	1.23	1.56
Q4	0.08778	0.06466	0.1746	1.09	0.96	1.24
World Regions of Origin						
Caribbean	-0.11214	0.40145	0.7800	.	.	.
East Asia & the Pacific	0.13862	0.34119	0.6845	.	.	.
Eastern Europe & Central Asia	0.16119	0.33580	0.6312	.	.	.
Latin America	0.14057	0.34032	0.6796	.	.	.
North Africa & Middle East	-0.09141	0.33831	0.7870	.	.	.
South Asia	-0.05581	0.33615	0.8681	.	.	.
Sub-Saharan Africa	0.04053	0.33778	0.9045	.	.	.
Western Europe & US	0.32610	0.78195	0.6767	.	.	.
Interaction Term						
Immigrant*Caribbean	-0.30404	0.51461	0.5275	1.21	0.68	1.73
Immigrant*East Asia & the Pacific	-1.02954	0.43747	<.0001	0.58	0.44	0.73
Immigrant*Eastern Europe & Central Asia	-0.82653	0.42590	<.0001	0.72	0.63	0.81
Immigrant*Latin America	-1.01724	0.43531	<.0001	0.59	0.48	0.71
Immigrant*North Africa & Middle East	-0.29181	0.42847	0.0100	1.22	1.03	1.42
Immigrant*South Asia	0.08453	0.42493	<.0001	1.78	1.59	1.98
Immigrant*sub-Saharan Africa	-0.50150	0.42847	0.8886	0.99	0.83	1.15
Immigrant*Western Europe & US	-0.59252	1.08539	0.9189	1.63	0.72	2.55

Families vs. long-term residents – 3+ multimorbidity

N=416,317 Families N=416,317 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	-0.36860	0.06444	<.0001	.	.	.
Age Categories						
30-49	1.28537	0.03591	<.0001	3.62	3.37	3.88
50+	3.20909	0.03298	<.0001	24.8	23.2	26.4
Sex (female)	-0.41142	0.01517	<.0001	0.66	0.64	0.68

N=416,317 Families N=416,317 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Neighborhood Income Quintiles						
Q1 (lowest income)	0.54641	0.02601	<.0001	1.73	1.64	1.82
Q2	0.39682	0.02653	<.0001	1.49	1.41	1.57
Q3	0.26838	0.02735	<.0001	1.31	1.24	1.38
Q4	0.18183	0.02817	<.0001	1.20	1.14	1.27
World Regions of Origin						
Caribbean	0.02763	0.05652	0.6250	.	.	.
East Asia & the Pacific	0.28395	0.04429	<.0001	.	.	.
Eastern Europe & Central Asia	0.15090	0.05191	0.0036	.	.	.
Latin America	0.10352	0.05649	0.0669	.	.	.
North Africa & Middle East	0.18183	0.06059	0.0027	.	.	.
South Asia	0.08612	0.04644	0.0637	.	.	.
Sub-Saharan Africa	0.06422	0.07308	0.3795	.	.	.
Western Europe & US	0.98778	0.41033	0.0161	.	.	.
Interaction Term						
Immigrant*Caribbean	0.32683	0.08378	<.0001	0.96	0.86	1.06
Immigrant*East Asia & the Pacific	-0.27643	0.06993	<.0001	0.53	0.50	0.56
Immigrant*Eastern Europe & Central Asia	-0.03477	0.08054	0.6660	0.67	0.61	0.73
Immigrant*Latin America	0.21366	0.08471	0.0117	0.86	0.77	0.95
Immigrant*North Africa & Middle East	0.05426	0.09308	0.5599	0.73	0.63	0.83
Immigrant*South Asia	0.44676	0.07081	<.0001	1.08	1.02	1.14
Immigrant*sub-Saharan Africa	0.07338	0.11071	0.5074	0.74	0.62	0.86
Immigrant*Western Europe & US	-0.16491	0.64873	0.7993	0.69	0.61	0.79

Economic vs. long-term residents – 3+ multimorbidity

N=585,539 Economic N=585,539 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	-0.77857	0.07647	<.0001	.	.	.
Age Categories						
30-49	1.27625	0.04658	<.0001	3.58	3.271	3.926
50+	2.50937	0.04690	<.0001	12.3	11.2	13.5
Sex (female)	-0.26554	0.01748	<.0001	0.77	0.74	0.79

N=585,539 Economic N=585,539 Long-term residents	Parameter Estimate	Standard Error	P value	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Neighborhood Income Quintiles						
Q1 (lowest income)	0.55537	0.02890	<.0001	1.74	1.65	1.84
Q2	0.41079	0.02984	<.0001	1.51	1.42	1.60
Q3	0.34992	0.03035	<.0001	1.42	1.34	1.51
Q4	0.16780	0.03165	<.0001	1.18	1.11	1.26
World Regions of Origin						
Caribbean	-0.03494	0.07231	0.6290	.	.	.
East Asia & the Pacific	-0.02897	0.04440	0.5141	.	.	.
Eastern Europe & Central Asia	-0.14732	0.04992	0.0032	.	.	.
Latin America	-0.10523	0.07203	0.1441	.	.	.
North Africa & Middle East	-0.20151	0.05637	0.0004	.	.	.
South Asia	-0.25340	0.04899	<.0001	.	.	.
Sub-Saharan Africa	-0.02143	0.07355	0.7708	.	.	.
Western Europe & US	-7.31092	30.65125	0.8115	.	.	.
Interaction Term						
Immigrant*Caribbean	0.84792	0.11104	<.0001	1.07	0.92	1.22
Immigrant*East Asia & the Pacific	-0.06406	0.08235	0.4366	0.43	0.41	0.45
Immigrant*Eastern Europe & Central Asia	0.25398	0.08871	0.0042	0.59	0.54	0.64
Immigrant*Latin America	0.47451	0.11766	<.0001	0.74	0.62	0.86
Immigrant*North Africa & Middle East	0.46314	0.09673	<.0001	0.73	0.65	0.82
Immigrant*South Asia	0.82098	0.08476	<.0001	1.04	0.98	1.12
Immigrant*sub-Saharan Africa	0.39956	0.12263	0.0011	0.69	0.55	0.83
Immigrant*Western Europe & US	8.45580	30.65947	0.7827	0.46	0.40	0.53

In chapter 4, we examined the risk of developing any chronic condition for immigrants compared to long-term residents by an immigrants' landing cohort (time of arrival to Canada using their landing year). We built three stratified models, by immigrant visa category, and adjusted for age, sex, neighborhood income quintiles and world region of origin. We included an interaction term for immigrant status*landing cohort to estimate the risk for immigrants, by different landing cohorts, when compared long-term residents, as depicted in the following formula:

Chronic Condition Outcomes= Immigrant (yes/no) + Age Category + Sex + Neighborhood level income + World Region of Origin + Immigrant*Landing Cohort

Chapter 4 Model Outputs

Refugees vs. long-term residents

N=151, 349 Refugees N=151, 349 Long-term Residents	Parameter Estimate	Standard Error	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	0.00162	0.07574	0.9830	.	.	.
Age Categories						
30-49	0.71599	0.00969	<.0001	2.05	2.01	2.09
50+	1.51838	0.01122	<.0001	4.57	4.47	4.67
Sex (female)	-0.04362	0.00730	<.0001	0.96	0.94	0.97
Neighborhood Income Quintiles						
Q1 (lowest income)	0.20116	0.01364	<.0001	1.22	1.19	1.26
Q2	0.17615	0.01411	<.0001	1.19	1.16	1.23
Q3	0.12175	0.01469	<.0001	1.13	1.10	1.16
Q4	0.08187	0.01527	<.0001	1.09	1.05	1.12
World Regions of Origin						
Caribbean	0.01773	0.08733	0.8391	2.07	1.99	2.15
East Asia & the Pacific	-0.12714	0.07724	0.0997	1.08	1.03	1.14
Eastern Europe & Central Asia	-0.10320	0.07581	0.1735	1.29	1.25	1.33
Latin America	-0.17302	0.07717	0.0250	1.08	1.03	1.14
North Africa & Middle East	0.00762	0.07613	0.9203	1.28	1.24	1.32
South Asia	0.45267	0.07543	<.0001	1.93	1.87	1.98
Sub-Saharan Africa	0.11449	0.07595	0.1317	1.61	1.55	1.68
Landing Cohort						
1996-1999	-0.15162	0.01429	<.0001	.	.	.
2000-2003	-0.26592	0.01580	<.0001	.	.	.
2004-2007	-0.43806	0.01707	<.0001	.	.	.
2008-2010	-0.75731	0.03415	<.0001	.	.	.
Interaction Term						
Immigrant*1996-1999	0.04754	0.01930	0.0138	.	.	.
Immigrant*2000-2003	0.15332	0.02069	<.0001	.	.	.
Immigrant*2004-2007	0.21801	0.02218	<.0001	.	.	.
Immigrant*2008-2010	0.38621	0.04302	<.0001	.	.	.

Immigrant (yes/no)*Landing Cohort	Hazard Ratio	95% Hazard Ratio Confidence Limits		P value
Immigrant yes vs no at Landing Cohort 1992-1995	1.00	0.84	1.16	0.5199
Immigrant yes vs no at Landing Cohort 1996-1999	1.05	0.88	1.22	0.0438
Immigrant yes vs no at Landing Cohort 2000-2003	1.17	1.00	1.34	0.0046
Immigrant yes vs no at Landing Cohort 2004-2007	1.25	1.05	1.45	<.0001
Immigrant yes vs no at Landing Cohort 2008-2010	1.47	1.25	1.69	<.0001

Families vs. long-term residents

N=416, 826 Families N=416, 826 Long-term Residents	Parameter Estimate	Standard Error	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	-0.46018	0.01404	<.0001	.	.	.
Age Categories						
30-49	0.61012	0.00599	<.0001	1.84	1.82	1.86
50+	1.65584	0.00579	<.0001	5.24	5.18	5.30
Sex (female)	-0.09751	0.00442	<.0001	0.91	0.90	0.92
Neighborhood Income Quintiles						
Q1 (lowest income)	0.24014	0.00742	<.0001	1.27	1.25	1.29
Q2	0.18158	0.00756	<.0001	1.20	1.18	1.22
Q3	0.14315	0.00771	<.0001	1.15	1.14	1.17
Q4	0.08681	0.00790	<.0001	1.09	1.07	1.11
World Regions of Origin						
Caribbean	0.54953	0.01600	<.0001	1.73	1.679	1.79
East Asia & the Pacific	0.18319	0.01411	<.0001	0.89	0.86	0.93

N=416, 826 Families N=416, 826 Long-term Residents	Parameter Estimate	Standard Error	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Eastern Europe & Central Asia	0.20460	0.01640	<.0001	1.23	1.19	1.27
Latin America	0.37192	0.01669	<.0001	1.25	1.16	1.28
North Africa & Middle East	0.20929	0.01887	<.0001	1.23	1.19	1.27
South Asia	0.60447	0.01398	<.0001	1.83	1.78	1.88
Sub-Saharan Africa	0.42962	0.01976	<.0001	1.54	1.48	1.60
Landing Cohort						
1996-1999	-0.13921	0.00808	<.0001	.	.	.
2000-2003	-0.29703	0.00868	<.0001	.	.	.
2004-2007	-0.55754	0.01089	<.0001	.	.	.
2008-2010	-0.85576	0.01864	<.0001	.	.	.
Interaction Term						
Immigrant*1996-1999	0.06682	0.01133	<.0001	.	.	.
Immigrant*2000-2003	0.14682	0.01194	<.0001	.	.	.
Immigrant*2004-2007	0.25395	0.01474	<.0001	.	.	.
Immigrant*2008-2010	0.38231	0.02455	<.0001	.	.	.

Immigrant (yes/no)*Landing Cohort	Hazard Ratio	95% Hazard Ratio Confidence Limits		P value
Immigrant yes vs no at Landing Cohort 1992-1995	0.63	0.61	0.65	<.0001
Immigrant yes vs no at Landing Cohort 1996-1999	0.68	0.66	0.70	<.0001
Immigrant yes vs no at Landing Cohort 2000-2003	0.73	0.71	0.75	<.0001
Immigrant yes vs no at Landing Cohort 2004-2007	0.81	0.79	0.83	0.0034
Immigrant yes vs no at Landing Cohort 2008-2010	0.93	0.88	0.98	0.0034

Economic vs. long-term residents

N=586,023 Economic N=586,023 Long-term Residents	Parameter Estimate	Standard Error	Pr > ChiSq	Hazard Ratio	95% Hazard Ratio Confidence Limits	
Immigrant (yes)	-0.47737	0.01506	<.0001	.	.	.
Age Categories						
30-49	0.72616	0.00726	<.0001	2.07	2.04	2.10
50+	1.40345	0.00779	<.0001	4.07	4.01	4.13
Sex (female)	-0.08413	0.00392	<.0001	0.92	0.91	0.93
Neighborhood Income Quintiles						
Q1 (lowest income)	0.23567	0.00641	<.0001	1.27	1.25	1.28
Q2	0.18748	0.00661	<.0001	1.21	1.19	1.22
Q3	0.14978	0.00673	<.0001	1.16	1.15	1.18
Q4	0.10389	0.00684	<.0001	1.11	1.10	1.13
World Regions of Origin						
Caribbean	0.72794	0.01952	<.0001	1.39	1.35	1.42
East Asia & the Pacific	0.21173	0.01471	<.0001	0.86	0.82	0.90
Eastern Europe & Central Asia	0.25735	0.01570	<.0001	0.90	0.78	1.05
Latin America	0.24641	0.02099	<.0001	0.84	0.72	0.98
North Africa & Middle East	0.24487	0.01696	<.0001	1.01	0.87	1.17
South Asia	0.65496	0.01500	<.0001	1.57	1.36	1.82
Sub-Saharan Africa	0.47829	0.02082	<.0001	1.12	0.97	1.30
Landing Cohort						
1996-1999	-0.17701	0.00708	<.0001	.	.	.
2000-2003	-0.33166	0.00733	<.0001	.	.	.
2004-2007	-0.52699	0.00930	<.0001	.	.	.
2008-2010	-0.87735	0.01610	<.0001	.	.	.
Interaction Term						
Immigrant*1996-1999	-0.09424	0.01041	<.0001	.	.	.
Immigrant*2000-2003	-0.01587	0.01052	0.1316	.	.	.
Immigrant*2004-2007	0.15936	0.01297	<.0001	.	.	.
Immigrant*2008-2010	0.41536	0.02121	<.0001	.	.	.

Immigrant (yes/no)*Landing Cohort	Hazard Ratio	95% Hazard Ratio Confidence Limits		P value
Immigrant yes vs no at Landing Cohort 1992-1995	0.62	0.60	0.64	<.0001
Immigrant yes vs no at Landing Cohort 1996-1999	0.57	0.55	0.59	<.0001
Immigrant yes vs no at Landing Cohort 2000-2003	0.61	0.59	0.63	<.0001
Immigrant yes vs no at Landing Cohort 2004-2007	0.73	0.71	0.75	0.0101
Immigrant yes vs no at Landing Cohort 2008-2010	0.94	0.90	0.98	0.0101