

Essays on healthcare utilization and cost patterns of immigrants and non-immigrants in Manitoba, Canada

By

Shantanu Debbarman

A Thesis submitted to the Faculty of Graduate and Post-doctoral Studies
of the University of Manitoba
in partial fulfilment of the requirements for the degree of

Doctor of Philosophy

Department of Economics
University of Manitoba
Winnipeg, Canada

Copyright © 2026 by Shantanu Debbarman

PhD Committee

Advisor: Dr. Marcelo Urquia

College of Community and Global Health
Rady Faculty of Health Sciences
University of Manitoba

Committee Members:

Dr. Julia Witt

Dr. Umut Oguzoglu

Department of Economics
University of Manitoba

Megan Delisle, MD, MSC, MPH, FRCSC

Surgery
Max Rady College of Medicine
University of Manitoba
Winnipeg, Canada

External Examiner: Dr Ruth Lavergne

Department of Family Medicine
Dalhousie University
Halifax, Canada

Declaration of Co-Authorship

I am the sole author of chapters 2, 3 and 4 of the text, analysis and results presentations in this dissertation.

Professor Marcelo L. Urquia and I conceived ideas and research designs for all the chapters collaboratively through extensive discussions. I framed the research questions, developed the methodologies, conducted the statistical analysis, and prepared the drafts of these chapters under his supervision.

Chapter 1, titled “Assessing the migrant mortality advantage among foreign-born and interprovincial migrants in Manitoba”, is co-authored with Heather Prior, Randy Walld and Dr. Urquia. I was the principal investigator.

Contribution to Chapter 1:

I identified the research topic, developed the research questions and design, wrote the literature reviews and relevant theories, developed quantitative techniques, analyzed the data, and interpreted the results. I drafted the first version of the manuscript.

Professor Urquia refined the research question, made a significant contribution to the study design, interpreted the results, and supervised the study.

Heather Prior and Randy Walld contributed to cleaning the dataset, analyzing the data, and interpreting the results.

Professors Julia Witt, Umut Oguzoglu, Urquia, and I are pursuing publication of Chapter 2, with me as the first author. They have made significant contributions to the study's design and interpretation and have provided thorough reviews and edits of the chapter on multiple occasions.

I intend to submit manuscripts for Chapters 3 and 4 to peer-reviewed journals in the future, where I will also serve as the principal author.

Abstract

Consisting of four chapters, this dissertation explores the mortality advantage among international and internal migrants and assesses healthcare utilization and costs at the End-Of-Life (EOL) for immigrants and non-immigrants. It also estimates healthcare use and costs among immigrants and non-immigrants over time, both after immigrants' arrival and during their health crises in Manitoba. Contemporary studies found that immigrants have better health upon arrival and are more likely to use aggressive care over EOL.

Chapter One compares mortality risks between immigrants, interprovincial migrants, and long-term residents in Manitoba (1985–2019) using a matched-cohort study. This study revealed immigrants' lower death risk compared to interprovincial migrants and long-term residents, alongside heterogeneity in death risk among immigrants using Cox and Poisson regressions.

Chapter Two compares EOL healthcare costs between immigrant and non-immigrant decedents (2005 - 2022) using Poisson and quantile regression models. This study found that immigrants incurred significantly higher overall healthcare costs in the EOL than non-immigrants, driven by inpatient hospital costs.

Chapter Three assesses whether healthcare use and costs among immigrants differ from those of non-immigrants over time, both upon arrival (forward analysis) and years before death (backward analysis), using Generalized Estimating Equations (GEE). This study found that for most years after arrival and the preceding years before death, immigrants incurred lower healthcare costs and had less healthcare use, but they were more likely to visit the emergency department and get admitted to the hospital during the year of death.

Chapter Four assesses differences in healthcare use and costs before and after cancer diagnoses between immigrants and non-immigrants. The study found that before diagnosis,

immigrants had lower healthcare costs and use, and after cancer diagnosis, costs increased with more inpatient and emergency care.

Together, these population-based studies advance our understanding of some characteristics and processes behind the healthy migrant effect, by including internal and international migrants and lifecourse approaches to health care use and costs from arrival to EOL. The insights gained may inform policies to promote timely access to healthcare for immigrants and to implement preventive strategies to reduce avoidable hospitalizations during health crises and at EOL.

Acknowledgements

I would like to express profound gratitude to my dissertation advisor, Dr. Marcelo Urquia, for his invaluable stewardship, consistent support, and encouragement throughout my doctoral journey. His insightful supervision and advice helped shape this dissertation and my development as a researcher. He was always available and offered valuable advice and feedback throughout my doctoral program. Without his guidance and support, this work would not have been possible.

I would also like to thank Dr. Julia Witt and Dr. Umut Oguzoglu for their time, enthusiasm, advice, and helpful feedback throughout this research. Their kind assistance, advice, and comments greatly shaped this study and helped me complete this thesis successfully. Dr. Umut Oguzoglu's expertise in econometrics and his engaging lectures in the Econometrics II course significantly enhanced my ability to develop robust quantitative models. I would like to thank Megan Delisle for her valuable advice and comments, drawn from her practical knowledge and experience, which helped in this research, especially in Chapter 4 and during the Mitacs Accelerate internship. I would like to thank Dr. Ruth Lavergne of Dalhousie University, the external examiner for my dissertation, for her insightful suggestions and comments, which improved the quality of this research and strengthened the final version of this dissertation.

I would like to express my appreciation to the faculty members of the Department of Economics, University of Manitoba, and Dr. Apurba K. Deb for their outstanding assistance and inspiration in completing my doctoral program. I acknowledge the Manitoba Centre for Health Policy (MCHP) for access to data in the Manitoba Population Research Repository under project #Debb-22044-23005, and Isuru Dharmasena and Heather Prior for organizing the datasets.

I owe my deepest personal gratitude to my wife, Sucheta Dey, for her sacrifices, hard work, support, and continued inspiration throughout my doctoral journey. I am deeply grateful to my son, Ishaan Debbarman, my parents and my younger brother, whose presence has been a constant source of joy, emotional support and inspiration. Finally, I am very grateful to my friends, sisters, brothers and uncles in Winnipeg for their love, emotional support, and inspiration.

This dissertation was funded by Professor Dr. Marcelo Urquia through his Canadian Institutes of Health Research grant [grant number FDN-154280].

Disclaimer

The data used in this study were obtained from the Manitoba Population Research Data Repository housed at the Manitoba Centre for Health Policy (MCHP), University of Manitoba, and were derived from information provided by Manitoba Health, Seniors and Long-term Care, Immigration, Refugees and Citizenship Canada (IRCC), Vital Statistics, Cancer Care Manitoba, Statistics Canada, Canadian Institute for Health Information (CIHI), and the Department of Families. The author acknowledges the Manitoba Centre for Health Policy for access to, and use of data contained within the Manitoba Population Research Data Repository under Project # 2023-005.

The findings and conclusions outlined in this thesis are those of the author and do not necessarily reflect the opinions or policies of the Manitoba Centre for Health Policy, Manitoba Health, or any data providers. No official endorsement by these organizations is intended or should be inferred.

Use of Artificial Intelligence

Generative artificial intelligence (AI) tools, such as Grammarly, were used solely to improve the grammar, word choice, and readability of portions of this thesis. All research questions, designs, analyses, results presentation, interpretations, and conclusions are the author's sole contribution and responsibility. The author has thoroughly reviewed and approved all AI-assisted revisions and accepts full accountability for the final content of this thesis.

Dedication

To my beloved parents, Madhusudan Debbarman and Lila Debbarman, whose unwavering love, steadfast emotional support, and countless sacrifices have been the foundation of my doctoral journey.

To my late father-in-law, Sachindra Kanti Dey, and my mother-in-law, Purnima Dey, whose love, emotional support, and inspiration made my doctoral program successful.

To my wife, Sucheta Dey, and my son, Ishaan Debbarman, who are my greatest sources of joy, inspiration, motivation, and strength.

To my younger brother Atanu Debbarman, his wife Shantan Mohajon, and our youngest family member, Ipsita Debbarman, whose love and inspiration helped me successfully complete my doctoral program.

And to my teachers, who guided me throughout my doctoral journey.

TABLE OF CONTENTS

INTRODUCTION	1
Background.....	1
Objectives	3
Analytical Approach	4
Contribution to Knowledge	5
References	6
Chapter 1 <u>ASSESSING THE MIGRANT MORTALITY ADVANTAGE AMONG FOREIGN-BORN AND INTERPROVINCIAL MIGRANTS IN MANITOBA, CANADA</u>	10
ABSTRACT	10
1.1 Introduction	12
1.2 Theory of the healthy migrant effect	15
1.2.1 Medical screening and immigration policy	16
1.2.2 Healthy lifestyle and diet habits	17
1.2.3 Self-selection.....	18
1.2.3.1 Human capital theory	19
1.2.4 Convergence hypothesis	21
1.2.5 Segmented assimilation hypothesis.....	22
1.2.6 Cultural framework and assimilation	24
1.3 Methods.....	25
1.3.1 Data sources	25
1.3.1.1 Ethics approval	25
1.3.2 Study Population	25
1.3.3. Study design.....	26
1.3.3.1 Matching technique.....	26
1.3.3.2 Variable definitions.....	27
1.3.3.2.1 Outcome Variables	27
1.3.3.2.2 Comparison groups.....	28
1.3.3.2.3 Socio-demographic Characteristics	28
1.3.4 Data analysis	30
1.3.4.1 Poisson regression.....	31
1.3.4.2 The Cox regression	32
1.3.4.3 Survival Curve (Kaplan-Meier Curve)	34

1.3.4.4. Inverse Probability of Censoring Weight (IPCW).....	35
1.4 Results.....	36
1.4.1 Description of the final sample sizes.....	36
1.4.1.1 Characteristics of the matched study population.....	37
1.4.2 All-cause mortality and premature mortality rates.....	42
1.4.3 Mortality according to the characteristics of foreign-born migrants.....	48
1.4.4 Mortality among Interprovincial migrants.....	50
1.5 Discussion	50
1.5.1 Main findings	50
1.5.2 Limitations	51
1.5.3 Interpretation.....	52
1.5.4 Policy Implication	54
1.6 Conclusion.....	54
1.7 References.....	55
Chapter 2 HEALTHCARE COSTS AT THE END-OF-LIFE AMONG IMMIGRANTS AND NON-IMMIGRANTS, MANITOBA, CANADA	65
ABSTRACT.....	66
2.1 Introduction	68
2.2 Methods.....	70
2.2.1 Data sources	70
2.2.2 Study Population	70
2.2.3 Variable definitions	70
2.2.3.1 Outcome variable.....	70
2.2.3.2 Comparison groups	72
2.2.3.3 Socio-demographic and other variables	72
2.2.4 Matching Criteria	72
2.2.5 Statistical Analysis	73
2.3 Results.....	73
2.3.1 Descriptive Statistics	73
2.3.2 Comparison of healthcare costs between immigrants and non-immigrants	74
2.3.3 Healthcare costs in the EOL among immigrant sub-groups.....	79
2.4 Discussion	79
2.4.1 Main Findings	79

2.4.2 Limitations	81
2.4.3 Interpretation	82
2.4.4 Implications for public health interventions, practices, and policies and future research	84
2.5 Conclusion	85
2.6 References	85
Chapter 3 TRAJECTORIES OF HEALTHCARE COSTS OF IMMIGRANTS AND NON-IMMIGRANTS IN MANITOBA	103
ABSTRACT	103
3.1 Introduction	106
3.2 Objectives	110
3.3 Methods	111
3.3.1 Data sources	111
3.3.2 Study design	111
3.3.2.1 Forward analyses	112
3.3.2.1.1 Cohort Criteria	112
3.3.2.1.2 Variable definitions	112
3.3.2.2 Backward analysis	114
3.3.2.2.1 Cohort Criteria	114
3.3.2.2.2 Variable definitions	114
3.3.3 Data analysis	114
3.3.3.1 Forward analysis	114
3.3.3.1.1 Endogeneity to omitted and selection bias	116
3.3.3.1.2 Inverse probability of censoring weights	120
3.3.3.2 Backward analyses	120
3.3.3.2.1 Data analysis	120
3.4 Results	121
3.4.1 Forward analysis	121
3.4.2 Backward Analysis	139
3.5 Discussion	149
3.5.1 Main findings	149
3.5.1.1 Summary of the results of forward analysis	149
3.5.1.2 Summary of the results of backward analysis	150

3.5.2 Limitations	150
3.5.3 Interpretation	151
3.5.3.1 Forward analysis	151
3.5.3.2 Backward analysis	152
3.6 Conclusion.....	154
3.7 References.....	154
Chapter 4 TRAJECTORIES OF HEALTHCARE COSTS BEFORE AND AFTER CANCER DIAGNOSIS AMONG IMMIGRANTS AND NON-IMMIGRANTS IN MANITOBA	166
ABSTRACT	1676
4.1 Introduction	170
4.1.1 Impact of Immigration Policy on Immigrant Health.....	171
4.1.2 Eligibility for Manitoba Healthcare Coverage and healthcare use of new Manitobans	171
4.1.3 Immigration population growth, composition, and mortality	172
4.1.4 Cancer incidence and mortality trends in Canada.....	173
4.1.5 Differences in overall and site-specific cancer incidence between immigrants and non- immigrants	174
4.1.6 Cancer outcomes of immigrants and non-immigrants	175
4.1.7 The number of years since immigration and cancer incidence and outcomes.....	176
4.1.8 Determinants of cancer risks in immigrants and non-immigrants	176
4.1.9 Cancer incidence and outcomes among immigrants and non-immigrants by sex	178
4.1.10 Research gaps.....	179
4.2 Objectives.....	181
4.3 Methods.....	183
4.3.1 Data sources	183
4.3.2 Cohorts and matching criteria	183
4.3.3 Variable definitions	185
4.3.4 Data analysis	187
4.3.4.1 Endogeneity due to omitted and selection bias	188
4.3.4.2 Inverse probability of censoring weights	191
4.4 Results.....	192
4.4.1 Descriptive Statistics	192
4.4.2 Comparisons of overall healthcare costs	198

4.4.3 Comparisons of healthcare use and costs by services	200
4.4.4 Healthcare costs differences among immigrants by years since immigration	203
4.5 Discussion	207
4.5.1 Main findings	207
4.5.2 limitations	208
4.5.3 Interpretation.....	209
4.5.4 Implications.....	211
4.6 Conclusion.....	212
4.7 References:.....	213
Chapter 5 GENERAL DISCUSSION.....	237
5.1 Healthy migrant effects: patterns and trends of healthcare use and costs.....	238
5.2 The routine healthcare deficit and crisis-driven healthcare	240
5.3 Heterogeneity in the healthcare system integration.....	241
5.4 Contributions to the literature.....	242
5.5 Policy and practical implications.....	242
5.6 Future research directions	243
5.7 References	2444

List of tables

Table 1.1: Definitions of dependent and independent variables.....	29
Table 1.2 Characteristics of the matched study population at the start of the follow up	38
Table 1.3: Person years and crude mortality rates (per 1000 person-years) for all-cause mortality among matched international Migrants (N=118,398), Interprovincial Migrants (N=118,398), and all other Manitobans (N=118,398).....	40
Table 1.4: Unadjusted and adjusted all-cause and premature mortality among international migrants, interprovincial migrants, and all other long-term Manitoba residents	44
Table 1.5: Unadjusted and adjusted incidence rate ratios for all-cause and premature mortality among matched International Migrants (N=118,398), Interprovincial Migrants (N=118,398), and all other long-term Manitoba residents(N=118,398), by period of start of follow-up.....	45
Table 1.6: Adjusted hazard ratios for all-cause and premature mortality among international migrants, interprovincial migrants, and all other Manitobans	46
Table 1.7: Unadjusted and adjusted incidence rate ratios for all-cause and premature mortality among international immigrants	49
Table 1.8: Crude and adjusted incidence rate ratios for all-cause and premature mortality among interprovincial migrants	50
Table 2.1: Socio-demographic characteristics and average healthcare costs (AC) of healthcare users during the last year of life, January 2004–March 2022.....	75
individuals with 1-2 comorbidities to \$38,874 (95% CI \$34,128, \$43,619) for those with 5 or more (p value for interaction <0.0001).	76
Table 2.2: The proportion of immigrants and non-immigrants utilizing various healthcare services and average costs during their final year of life, Manitoba, Canada, 2005-2022	77
Table 3.1: Socio-demographic characteristics and average annual healthcare costs (AC) during 1995–2023	122
Table 3.2: Trends in Healthcare Service Use: Immigrants vs. Non-Immigrants.....	125
Table 3.3: Trends in cumulative average annual healthcare service costs with 95% CI over 15 years of follow-up: Immigrants vs. Non-Immigrants	128
Table 3.4: Trajectories of average annual healthcare costs, including unadjusted	131
and adjusted mean differences between immigrants and non-immigrants.....	131
Table 3.5: Unadjusted and adjusted odds ratios for annual healthcare use between immigrants and non-immigrants by healthcare services	133
Table 3.6: Trajectories of unadjusted and adjusted mean differences in annual healthcare costs between immigrants and non-immigrants, stratified by sex.....	137
Table 3.7: Socio-demographic characteristics and average annual healthcare costs (AC) during January 1995–March 2023	140
Table 3.8: Trends in cumulative average annual healthcare service costs with 95% CI over the last 10 years of follow-up: Immigrants vs. Non-Immigrants	142
Table 3.9: Trajectories of average annual healthcare costs from the year of death backward among immigrants and non-immigrants who died between January 1997 and March 2023.....	145

Table 3.10: Unadjusted and adjusted mean differences in annual healthcare costs between immigrants and non-immigrants by healthcare services	146
Table 4.1: Socio-demographic characteristics and average annual healthcare costs (AC) during January 1995–March 2023 among cancer patients	193
Table 4.2: Patterns of Healthcare Service Use Among Immigrants and Non-Immigrants Before and After Cancer Diagnosis.....	196
Table 4.3: Unadjusted and adjusted differences in annual health care costs for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs. non-immigrants.....	198
Table 4.4: Unadjusted and adjusted odds ratios for healthcare utilization and differences in annual healthcare costs by services for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs non-immigrants.....	200
Table 4.5: Unadjusted and adjusted differences in annual health care costs (\$CA) among international migrant cancer patients diagnosed between 1995 and 2022 by Years Since Immigration (YSI).....	204
Table 4.6: Unadjusted and adjusted odds ratios for healthcare utilization and differences in annual healthcare costs by services for cancer patients diagnosed between 1995 and 2022, comparing YSI ≤ 10 years vs YSI > 20 (reference group).....	205

List of figures

Figure 1.1: Survival curves for all-cause mortality (Panel A) and premature mortality (Panel B) among matched international immigrants, interprovincial migrants and all other Manitobans	47
Panel A	47
Figure 2.1: Mean differences in health care expenditure in the EOL between immigrants and non-immigrants	78
Figure 2.2: The estimated differences in healthcare expenditure in the EOL between immigrants and non-immigrants (adjusted) using Quantile regression.....	80
.....	80
Figure 2.3: Mean differences in health care expenditure in the last year of life between immigrant subgroups.....	81
Figure 3.1: Trend of cumulative average healthcare costs over the 15 years among immigrants and non-immigrants	129
Figure 3.2: Trend of cumulative average healthcare costs over 15 years among immigrants and non-immigrants who were aged 20 to 40 at baseline.	129
Figure 3.3: Trend of cumulative average healthcare costs over 15 years among immigrants and non-immigrants who were aged 41 to 60 at baseline.	130
Figure 3.4: Trend of cumulative average over the last 10 years of life among immigrants and non-immigrants	143

List of appendices

Appendix I.1 Data Linkage	62
Appendix I.2 Balance Assessment of Matching Variables Between Immigrants and All-Other Manitobans in the Matched Cohort.....	63
Appendix I.3 Balance Assessment of Matching Variables Between Immigrants and interprovincial migrants in the Matched Cohort.....	63
Appendix I.4 Person-years and crude mortality rates (per 1000 person-years) for all-cause mortality among international Migrants (N=118,398), Interprovincial Migrants (N=118,398), and all other Manitobans (N=118,398) by Regional Health Authority	64
Appendix I.5 Unadjusted and adjusted incidence rate ratios for all-cause and premature mortality among comparison groups by Regional Health Authority	64
Appendix I.6 Age distribution of Immigrants by immigrant type (primary or secondary)	65
Appendix I.7 Age distribution of Immigrants by immigrant type (primary or secondary)	65
(PMR cohort, Age < 71).....	65
Appendix II.1 list of variables	90
Appendix II.2 Methods of cost estimation	94
Appendix II.3 Mean differences in healthcare expenditure in the last year of life between immigrants and non-immigrants (adjusted) by sex using Quantile regression	101
Appendix II.4 Hospitalization in the last year of life by immigration status and LTC use	102

Appendix II.5 Unadjusted and adjusted odds ratios for hospitalization between immigrants and non-immigrants by LTC stay (p-value of interaction between immigration status and LTC stay is <0.0001).	102
Appendix II.6 Percentage of users and average healthcare costs for the healthcare facilities among immigrants by sex.	102
Appendix III.1: Trends in average annual healthcare service costs with 95% CI: Immigrants (IM) vs. Non-Immigrants (NIM)	160
Appendix III.2: Trajectories of unadjusted and adjusted mean differences in annual healthcare costs between immigrants and non-immigrants stratified by baseline age groups (P-value of interaction between age groups and immigrant status is <.0001).	161
Appendix III.3: Unadjusted and adjusted odds ratios for annual healthcare use between immigrants and non-immigrants by healthcare services and baseline age groups	162
Appendix III.4: Trajectories of unadjusted and adjusted odds ratios of annual inpatient healthcare use between immigrants and non-immigrants, stratified by sex.	164
Appendix III.5 Unadjusted and adjusted odds ratios of annual healthcare use between immigrants and non-immigrants by healthcare services over the last 10 years of life.	165
Appendix IV.1: Mortality rates among immigrant and non-immigrant cancer patients within three years after diagnosis between 1995 and 2022.	222
Appendix IV.2: Unadjusted and adjusted differences in annual health care costs (CA\$) between immigrants and non-immigrants cancer patients by survivors and decedents	223
Appendix IV.3: Unadjusted and adjusted odds ratios for healthcare utilization and differences in annual costs for healthcare services stratified by end of follow-up status (died or survivor) for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs non-immigrants.	224
Appendix IV.4: Unadjusted and adjusted odds ratios for healthcare utilization at Cancer Care Manitoba after diagnosis between 1995 and 2022, comparing immigrants vs non-immigrants.	228
Appendix IV.5: Unadjusted and adjusted differences in annual health care costs between 1995 and 2022, comparing cancer patient immigrants vs non-immigrants, by sex (p-value of interaction between immigrant*sex=0.70)	229
Appendix IV.6: Sensitivity Analysis: Without those diagnosed with stage 4 cancer or with nonmelanoma skin cancer	230
Appendix IV6.1 Patterns of Healthcare Service Use Among Immigrants and Non-Immigrants Before and After Cancer Diagnosis.	230
Appendix IV6.2 Mortality rates among immigrant and non-immigrant cancer patients within three years after diagnosis between 1995 and 2022.	231
Appendix IV6.3 Unadjusted and adjusted differences in annual health care costs for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs. non-immigrants.	232
Appendix IV6.4 Unadjusted and adjusted odds ratios for healthcare utilization and differences in annual healthcare costs by services for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs non-immigrants.	233
Appendix IV6.5 Unadjusted and adjusted odds ratios for healthcare utilization at Cancer Care Manitoba after diagnosis between 1995 and 2022, comparing immigrants vs non-immigrants.	235

Appendix IV 6.6 Unadjusted and adjusted differences in annual health care costs between immigrant and non-immigrant cancer patients by survivors and decedents	236
Appendix IV 6.7 Unadjusted and adjusted differences in annual health care costs between immigrant and non-immigrant cancer patients by sex (p-value of interaction between immigrant*sex=0.89)	237

INTRODUCTION

Background

The proportion of the immigrant population has been steadily increasing over the years. Statistics Canada forecasted that around 31.8% of Canada's total population would be immigrants by 2041 (Statistics Canada, 2020). About 75% of Manitoban immigrants who arrived between 1985 and 2017 landed after 1999. Since 1985, Asia has been the main source of immigrants to Manitoba, accounting for 62% of total immigration; furthermore, 47% of incoming immigrants were aged 25 to 44 (Urquia et al., 2020). Permanent residents and work permit holders in Manitoba can apply for health coverage from the date they arrive, but they must wait approximately 4 weeks for processing (Manitoba Health, 2024).

Contemporary studies on migrant health show that migrants often have better health upon arrival compared to non-migrants, a phenomenon known as the Health Migration Effect (Abraido-Lanza et al., 1999; Anson, 2004; Rosenwaike & Hempstead, 1990; Sharma et al., 1990). However, some research suggests that migrants may face more health risks (DesMeules et al., 2005; Gadd et al., 2006; Nielsen & Krasnik, 2010; Hollander et al., 2012; Norredam et al., 2012; Moullan & Jusot, 2014). Recent studies in Canada have found that immigrants have a mortality advantage and experience fewer chronic diseases compared to the Canadian-born population (Cheung et al., 2017; Lu and Ng, 2019; Debbarman et al., 2023), while this health advantage varies among different immigrant groups based on their immigration characteristics (Debbarman et al., 2023) and length of stay (Cheung et al., 2017).

Selecting healthy immigrants through immigration policy could improve immigrants' health outcomes (Ali et al., 2004; DesMeules et al., 2005; Newbold, 2006; Omariba et al., 2014).

However, refugees and certain family categories were exempt from the excessive-demand inadmissibility under the Immigration and Refugee Protection Act (IRPA, 2002; Lu, C., and Ng, E., 2019). Additionally, refugees may have faced adversity before or during migration (DesMeules et al., 2005; Hollander et al., 2012; Norredam et al., 2012). Furthermore, circumstances prior to immigration, such as economic situation, educational attainment, and healthcare facilities in their home countries, might have contributed to delayed access to healthcare (Marmot M and Bell R., 2012; Fortuna et al., 2008; Jatrana et al., 2014; Pati et al., 2023), thereby leading to severe health issues at the End-of-Life (EOL) (Marmot M and Bell R; Fortuna et al., 2008; Pati et al., 2023; Sangalang et al., 2019).

Immigrants' health conditions might decline over time due to stress and the challenges of integrating into a new society. This includes adopting a new lifestyle in the host country and changing dietary habits, which can lead to their health converging with that of non-immigrants (McDonald and Kennedy, 2005; Ng et al., 2011; Vang et al., 2015; Cheung et al., 2017; Constant, 2017; Holz, 2022). Additionally, delays in accessing healthcare support, along with barriers such as language, low socio-economic status, educational background, cultural differences, and lack of social inclusion, may singly or collectively contribute to a decline in the health status of immigrants as their duration of stay increases (Steele et al., 2002; Leburn, 2012; Subedi & Rosenberg, 2014; Patel et al., 2019; Niraula et al., 2023).

Studies on EOL healthcare utilization patterns between immigrants and non-immigrants found that immigrants are more likely to undergo aggressive treatments and be admitted to intensive care units during EOL than non-immigrants (Quanch et al., 2021; Yarnell et al., 2017; Yarnell et al., 2020; Chu et al., 2021). Additionally, a greater proportion of immigrants die in hospitals compared to non-immigrants (Spall et al., 2021; Lees et al., 2024; Yarnell et al., 2020).

As immigrants face barriers and delays in accessing healthcare (Leburn, 2012; Wang et al., 2019), resulting immigrants' health may decline over time and accumulate comorbidities (Rouhani et al., 2024), which leads to a tendency for more aggressive interventions during health crises and EOL (Quach et al., 2021; Yarnell et al., 2017; Yarnell et al., 2020; Chu et al., 2021), despite many arriving in better health (Cheung et al., 2016; Debbarman et al., 2022; Lu and Ng, 2019). Therefore, understanding the differences in healthcare use and costs between immigrants and non-immigrants, especially when these patterns intersect, is essential for immigrants' integration into the healthcare system and for ensuring timely access to healthcare. Additionally, research on the overall patterns of healthcare use and costs among immigrants and non-immigrants at the end-of-life is limited to date.

Objectives

The first goal of this study is to assess the mortality advantage among foreign-born and interprovincial migrants compared to non-immigrants.

The second objective is to examine patterns of healthcare use and related costs among Immigrants and non-immigrants during EOL.

The third objective is to examine trends in healthcare use and costs over an extended period after arrival, as well as from the year of death backward to the preceding years.

Finally, this study examined healthcare use and cost patterns among immigrants and non-immigrants before and after a cancer diagnosis. Furthermore, it compares healthcare use and costs between immigrants and non-immigrants by sex and explores differences among immigrants by years since immigration.

Analytical Approach

For this study, Immigration, Refugees and Citizenship Canada (IRCC)'s permanent resident dataset was used to determine immigrant status. The Manitoba Health Insurance Registry was employed to identify eligible individuals for the cohort and to gather socio-demographic information. Relevant Healthcare datasets, including medical, drug, hospital, home care, emergency department, and long-term care data, were utilized. The Vital Statistics Mortality database was used to establish causes of death. Additional datasets were used to measure covariates, such as rent assistance (Rent Aid database), welfare (Employment and Income Assistance database), and neighbourhood income quintiles (Canadian Censuses). All datasets were linked using scrambled Personal Health Identification Numbers.

To assess the presence of a healthy migrant effect among immigrants, I employed a retrospective population-based matched-cohort design and the Kaplan-Meier curve, along with Cox and Poisson regressions, to analyze premature mortality (deaths up until age 70) and all-cause mortality from January 1985 to March 2019 among immigrants, interprovincial migrants and long-term residents (all other Manitobans) in Manitoba.

To compare overall healthcare costs during the EOL between immigrants and non-immigrants aged 50 or older at the time of death, who died between January 1, 2005, and March 31, 2022, and had valid health registrations in the Manitoba Health Insurance Registry (the Registry), I used a retrospective matched design with a Zero-Inflated Gamma Hurdle model for right-skewed cost data and quantile regression, with costs expressed in 2022 Canadian dollars.

To examine the patterns of healthcare use and costs among immigrants and non-immigrants over an extended period after immigrants' health coverage began, this study employed a forward-looking, longitudinal approach. To investigate healthcare use and costs from

the year of death backwards, the study applied a backward-looking, longitudinal approach. The population study used a GEE regression with a gamma distribution and log link with a two-part hurdle model for comparing healthcare overall cost patterns between immigrants and non-immigrants: the first part used a logit model to determine whether an individual incurred any annual healthcare costs, while the second part used GEE with a log link, a gamma distribution, first-order autocorrelation for right-skewed cost data and repeated measurements. In addition, odds ratios for healthcare use over time between immigrants and non-immigrants were estimated using GEE with a binomial distribution and a logit model for repeated observations. In addition, the study used inverse probability censoring weights in the forward analysis to address information loss due to follow-up after death and/or out-migration (Howe et al., 2016). Additionally, to address unobserved and selection bias among immigrants before and after immigration, I used the two-stage residual inclusion model suggested by Terza et al. (2008).

Finally, to compare patterns of healthcare use and costs incurred for pre-and post-cancer diagnosis using longitudinal data, the matched study used the same statistical techniques used for the population study analysis. To address bias in estimates arising from censoring due to death or outmigration in both longitudinal population and matched studies, I used the Inverse Probability of Censoring Weight (Howe et al., 2016). In addition, to address unobserved and selection bias among immigrants before and after immigration, I used the two-stage residual inclusion model suggested by Terza et al. (2008).

Contribution to Knowledge

The findings of this study may help understand when and which subgroups experience shifts in healthcare use and costs, as well as the impact of delayed access on healthcare use and

costs during a health crisis or EOL. It may help to develop appropriate policies to integrate immigrants into the healthcare system and to support them in receiving timely healthcare.

References

Abraído-Lanza, A.F., Dohrenwend, B.P., Ng-Mak, D.S., & Turner, J.B. (1999). The Latino mortality paradox: A test of the “salmon bias” and healthy migrant hypotheses. *American Journal of Public Health*, 89(10): 1543–1548.

Ali, J.S., McDermott, S., & Gravel, R.G. (2004). Recent research on immigrant health from Statistics Canada’s population surveys. *Canadian Journal of Public Health*, 95(3).

Anson, J. (2004). The migrant mortality advantage: A 70-month follow-up of the Brussels population. *European Journal of Population*, 20(3): 191–218.

Cheung, M. C., Earle, C. C., Fischer, H. D., Camacho, X., Liu, N., Saskin, R., Shah, B. R., Austin, P. C., & Singh, S. (2017). Impact of Immigration Status on Cancer Outcomes in Ontario, Canada. *Journal of Oncology Practice*, 13(7): e602–e612.

Chu A, Barbera L, Sutradhar R, Oz U E, O’Leary E, Seow H. (2021). Association between end-of-life cancer care and immigrant status: A retrospective cohort study in Ontario, Canada. *BMJ Open*. 11(6).

Constant, A. F., Garcia-Munoz, T., Neuman, S., & Neuman, T. (2017). A “healthy immigrant effect” or a “sick immigrant effect”? Selection and policies matter. *The European Journal of Health Economics*, 19(1): 03–121.

Debbarman, S., Prior, H., Walld, R., & Urquia, M. L. (2023). Assessing the migrant mortality advantage among foreign-born and interprovincial migrants in Manitoba, Canada. *Canadian Journal of Public Health*, 114(3): 441–452.

DesMeules, M., Gold, J., McDermott, S., Cao, Z., Payne, J., Lafrance, B., et al. (2005). Disparities in mortality patterns among Canadian immigrants and refugees, 1980-1998: Results of a national cohort study. *Journal of Immigrant Health*, 7(4): 221–232.

Fortuna L R, Porche M V, Alegria M. (2008). Political violence, psychosocial trauma, and the context of mental health services use among immigrant Latinos in the United States. *Ethn. Health*, 13(5): 435–63.

Gadd, M., Johansson, S. E., Sundquist, J., & Wändell, P. (2006). Are there differences in all-cause and coronary heart disease mortality between immigrants in Sweden and in their country of birth? A follow-up study of total populations. *BMC Public Health*, 6: 1–9.

Hollander, A.C., Bruce, D., Ekberg, J., Burström, B., Borrell, C., & Ekblad, S. (2012). Longitudinal study of mortality among refugees in Sweden. *International Journal of Epidemiology*, 41(4): 1153–1161.

- Holz, M. (2022). Health inequalities in Germany: differences in the “Healthy migrant effect” of European, non-European and internal migrants. *Journal of Ethnic and Migration Studies*, 48(11): 2620–2641.
- Howe, C. J., Cole, S. R., Lau, B., Napravnik, S., & Joseph J., E. (2016). Selection Bias Due to Loss to Follow Up in Cohort Studies. *Epidemiology*, 27(1): 91–97.
- Jatrana S, Pasupuleti S S R, & Richardson K. (2014). Nativity, duration of residence and chronic health conditions in Australia: Do trends converge towards the native-born population? *Soc. Sci. Med.* 119: 53–63.
- Justice Laws Website (2001). Part 1 Immigration to Canada DIVISION 4 Inadmissibility Sections 36-38 in Immigration and Refugee Protection Act (s.c.2001, c.27). Accessed May 22, 2018.
- Lebrun, L. A. (2012). Effects of length of stay and language proficiency on health care experiences among Immigrants in Canada and the United States. *Social Science and Medicine*, 74(7): 1062–1072.
- Lees C S, Seow H, Chan K K W, Gayowsky A, Merchant S J, & Sinnarajah A. (2024). Sex-Based Analysis of Quality Indicators of End-of-Life Care in Gastrointestinal Malignancies. *Current Oncology*, 31(3):1170–1182.
- Lu, Chaohui, & Edward Ng (2019). Healthy Immigrant Effect by Immigrant Category in Canada. *Heath Reports*, 30 (4); 3–11.
- Manitoba Health (2024). Manitoba Healthcare Coverage. Website: <https://www.gov.mb.ca/health/mhsip/index.html>.
- Marmot M, & Bell R. (2012). Fair society, healthy lives. *Public Health*, 126 (SUPPL.1): 4-10.
- McDonald T. J. & Kennedy S. (2005). Is migration to Canada associated with unhealthy weight gain? Overweight and obesity among Canada’s immigrants. *Social Science and Medicine*, 61: 2469–2481.
- Moullan, Y., & Jusot, F. (2014). Why is the “healthy immigrant effect” different between European countries? *European Journal of Public Health*, 24 (SUPPL.1): 80–86.
- Newbold, K. B. (2006). Chronic conditions and the healthy immigrant effect: Evidence from Canadian immigrants. *Journal of Ethnic and Migration Studies*, 32(5): 765–784.
- Ng E., Pottie K., & Spitzer D. (2011). Official language proficiency and self-reported health among immigrants to Canada. *Health Reports*, 22(4): 15–23.
- Nielsen, S.S., & Krasnik, A. (2010). Poorer self-perceived health among migrants and ethnic minorities versus the majority population in Europe: A systematic review. *International Journal of Public Health*, 55(5): 357–371.

- Niraula, A., Ratti, N., Colley, M., Rosenberg, M., Ghassemi, E., & Wilson, K. (2023). Negotiating precarity: Recent immigrants' perceptions of waiting for public healthcare in Ontario, Canada. *Health Policy*, 133: 104843–104843.
- Norredam, M., Olsbjerg, M., Petersen, J.H., Juel, K., & Krasnik, A. (2012). Inequalities in mortality among refugees and immigrants compared to native Danes - A historical prospective cohort study. *BMC Public Health*, 12(757).
- Omariba, D.W.R., Ng, E., & Vissandjée, B. (2014). Differences between immigrants at various durations of residence and host population in all-cause mortality, Canada 1991-2006. *Population Studies*, 68(3): 339–357.
- Patel, A., Dean, J., Edge, S., Wilson, K., & Ghassemi, E. (2019). Double burden of rural migration in Canada? Considering the social determinants of health related to immigrant settlement outside the cosmopolis. *International Journal of Environmental Research and Public Health*, 16(5): 678-.
- Pati S, Sinha A, Verma P, Kshatri J, Kanungo S, & Sahoo K C, et al. (2023). Childhood health and educational disadvantage are associated with adult multimorbidity in the global south: Findings from a cross-sectional analysis of nationally representative surveys in India and Brazil. *J. Epidemiol Community Health*, 2023;77(10): 617–624.
- Quach B I, Qureshi D, Talarico R, Hsu A T, & Tanuseputro P. (2021). Comparison of End-of-Life Care Between Recent Immigrants and Long-standing Residents in Ontario, Canada. *JAMA Netw Open*, 4(11): e2132397.
- Rosenwaike, I., & Hempstead, K. (1990). Mortality among three Puerto Rican populations: residents of Puerto Rico and migrants in New York City and in the balance of the United States, 1979-81. *International Migration Review*, 24(4): 684–702.
- Rouhani, Setareh, et al. “Risk of Developing Multimorbidity among Previously Healthy Immigrants and Long-Term Ontario Residents.” *The Open Public Health Journal*, vol. 17, no. 1.
- Sangalang C C, Becerra D, Mitchell F M, Lechuga-Peña S, Lopez K, & Kim I. (2019). Trauma, Post-Migration Stress, and Mental Health: A Comparative Analysis of Refugees and Immigrants in the United States. *J Immigr Minor Health*. 21(5): 909–919.
- Sharma, R.D., Michalowski, M., & Verma, R.B. (1990). Mortality differentials among immigrant populations in Canada. *International Migration*, 28(4): 443–450.
- Spall H G C V, Hill A D, Fu L, Ross H J, & Fowler R A. (2021). Temporal trends and sex differences in intensity of healthcare at the end-of-life in adults with heart failure. *J Am Heart Assoc.*, 10(1):1–18.
- Statistics Canada: <https://www150.statcan.gc.ca/n1/daily-quotidien/220204/dq220204b-eng.htm>
- Steele, L. S., Lemieux-Charles, L., Clark, J. P., & Glazier, R. H. (2002). The Impact of Policy Changes on the Health of Recent Immigrants and Refugees in the Inner City: A Qualitative Study of Service Providers' Perspectives. *Canadian Journal of Public Health*, 93(2): 118–122.

- Subedi, R. P., & Rosenberg, M. W. (2014). Determinants of the variations in self-reported health status among recent and more established immigrants in Canada. *Social Science and Medicine*, 115: 103–110.
- Terza, J. V., Basu, A., & Rathouz, P. J. (2008). Two-stage residual inclusion estimation: Addressing endogeneity in health econometric modelling. *Journal of Health Economics*, 27(3): 531–543.
- Urquia M, Walld R, Prior H, Detillieux G, Eze N, & Koseva I. (2020). The Diversity of Immigrants to Manitoba, Migration Dynamics and Basic Healthcare Service Use. Manitoba Centre for Health Policy.
- Vang Z, Sigouin J, Flenon A, Gagnon, A. (2015). *The Healthy Immigrant Effect in Canada: A Systematic Review*. Population Change and Life Course Strategic Knowledge Cluster Discussion Paper Series 2015; 3(1): Article 4.
- Wang, Lu, et al. “Older Immigrants’ Access to Primary Health Care in Canada: A Scoping Review.” *Canadian Journal on Aging* [CAMBRIDGE], vol. 38, no. 2, June 2019, pp. 193–209.
- Yarnell C J, Fu L, Bonares M J, Nayfeh A, & Fowler R A. (2020). Association between Chinese or South Asian ethnicity and end-of-life care in Ontario, Canada. *Journal of Canadian Medical Association*, 192(11): E266–274.
- Yarnell C J, Fu L, Manuel D, Tanuseputro P, Stukel T, & Pinto R, et al. (2017). Association between immigrant status and end-of-life care in Ontario, Canada. In: *Journal of the American Medical Association*, 318 (15): 1479–1488.

CHAPTER 1

ASSESSING THE MIGRANT MORTALITY ADVANTAGE AMONG FOREIGN-BORN AND INTERPROVINCIAL MIGRANTS IN MANITOBA, CANADA

ABSTRACT

Objectives: Studies on mortality differences between international immigrants and non-immigrants have shown mixed results. Mortality among interprovincial migrants has been less extensively studied. Our objectives were to compare mortality risk between international immigrants, interprovincial migrants, and all other long-term residents of Manitoba, Canada, and to identify factors associated with mortality among migrants.

Methods: We conducted a retrospective matched-cohort study to evaluate all-cause and premature mortality among 355,194 individuals, including international immigrants, interprovincial migrants, and long-term Manitoba residents (118,398 in each group), from January 1985 to March 2019, using linked administrative databases. Cox proportional hazards and Poisson regression models were used to calculate adjusted hazard ratios (aHRs) and adjusted incidence rate ratios (aIRRs), along with 95% confidence intervals (CIs).

Results: The all-cause mortality risk was lower among international immigrants (2.3 per 1000 individuals) and interprovincial migrants (4.4 per 1000) compared to long-term Manitobans (5.6 per 1000) (aIRR: 0.43; 95% CI: 0.42, 0.45) and (aIRR: 0.81; 95% CI: 0.80, 0.84, respectively). International immigrants had a lower death risk than interprovincial migrants (aIRR: 0.53; 95% CI: 0.50, 0.55). Similar patterns appeared for premature mortality. Among international immigrants, refugees, individuals from North America and Oceania, and those with low

educational attainment showed higher mortality risks. Among internal migrants, individuals from Eastern Canada had a lower mortality risk than those migrating from Ontario and Western Canada.

Conclusions: Migrants had a survival advantage over non-migrants, especially among international immigrants compared to interprovincial migrants. There was variability in mortality risk between the two migrant groups, depending on migrants' characteristics.

Note: An abridged version of this chapter has been published as

Debbarman, S., Prior, H., Walld, R., & Urquia, M. L. (2023). Assessing the migrant mortality advantage among foreign-born and interprovincial migrants in Manitoba, Canada. *Canadian Journal of Public Health*, 114(3): 441–452. <https://doi.org/10.17269/s41997-022-00727-4>

1.1 Introduction

Evidence regarding the health status of immigrants compared to non-immigrants has yielded mixed results. Some studies indicate an immigrant advantage (Abraído-Lanza et al., 1999; Anson, 2004; Rosenwaike & Hempstead, 1990; Sharma et al., 1990), while others show increased risks (Gadd et al., 2006; Sundquist & Li, 2006; DesMeules et al., 2005; Solé-Auró & Crimmins, 2008; Nielsen & Krasnik, 2010; Hollander et al., 2012; Norredam et al., 2012; Moullan & Jusot, 2014). These differing findings are influenced by variations in study methods, baseline health risks among non-immigrants, immigrant composition, and study populations. For instance, in countries that mainly accept immigrants on humanitarian grounds, such as Sweden, immigrants tend to have higher rates of heart disease than the native-born (Gadd et al., 2006; Sundquist & Li, 2006).

Refugees often face adverse conditions before or during migration (DesMeules et al., 2005; Hollander et al., 2012; Norredam et al., 2012). In contrast, studies from countries that mainly receive economic migrants—those who choose to migrate themselves—such as Canada and the United States, typically report lower mortality rates among international immigrants compared to non-migrants (Abraído-Lanza et al., 1999; Anson, 2004; Rosenwaike & Hempstead, 1990; Sharma et al., 1990; Khan et al., 2017), including overall and cause-specific mortality (Ng & LHAD Research Team, 2011; Omariba et al., 2014). The idea of Migrant Mortality Advantage (MMA), closely linked to the healthy immigrant paradigm (Beiser, 2005), supports these empirical findings in high-income countries (Razum, 2008).

However, the reasons for the lower mortality among immigrants remain unclear. Possible factors influencing the MMA include healthy immigrant selection, the “salmon bias,” and convergence over time. Selective migration can result from both host-country immigration

policies and self-selection, where healthier individuals are more likely to migrate. Applicants are chosen through a points system that values higher education levels, work experience, and other traits linked to successful economic integration. They must also pass a medical exam, and those who might threaten public health or safety or place an excessive burden on health or social services may be deemed inadmissible. Evidence of favourable sociodemographic traits supports the idea of selective migration, as these traits are associated with healthier behaviours and outcomes, including lower mortality, compared to non-migrants (Ali et al., 2004; DesMeules et al., 2005; Newbold, 2006; Omariba et al., 2014).

A second common hypothesis, known as the “Salmon bias,” suggests that some immigrants return to their country of origin after retirement, temporary employment, or serious illness. Consequently, their deaths happen outside the host country and are not recorded in the host country's mortality statistics. Under this hypothesis, the lower mortality rates observed among immigrants are viewed as an artifact caused by including immigrants in the denominator but not in the numerator, creating a “statistically immortal” bias that artificially lowers immigration mortality rates (Abraído-Lanza et al., 1999; Wallace & Kulu, 2018). This phenomenon is especially common among those with long-term illnesses (Valles, 2016), retirees (Abraído-Lanza et al., 1999), or individuals facing challenges in adapting to a new society or experiencing financial hardships (Razum et al., 1998).

A study conducted in England and Wales observed the MMA with salmon bias among immigrants from Bangladesh, India, Pakistan, and the Caribbean. It noted MMA without salmon bias among other immigrant groups (Wallace and Kulu, 2018). The salmon bias effect among immigrants may vary by age. A study by Turra and Elo (2008) identified the salmon bias effect at age 65 and older, but the magnitude was too small. Additionally, years since migration may be

related to the health of immigrants returning to their home country. Riosmena, Wong, and Palloni (2013) found that remigrants who had stayed in the United States for fewer than 15 years had worse health than immigrants with the same length of stay. A study among returnees from England to Scotland, or vice versa, found that English men were less likely to suffer from limiting long-term illness (LLTI) than the populations of their origin and host countries (England and Scotland, respectively), but did not observe any salmon bias.

In contrast, female return migrants had notably lower odds of suffering from LLTI compared to the population of their country of origin (Wallace and Kulu, 2014b). It is important to recognize that sick immigrants are often more inclined to stay in the host country because of its better healthcare system and easier access to medical resources (Norredam et al., 2015; Razum et al., 1998). Furthermore, having blood-related family members already settled in the host country can greatly influence their decision to remain, thereby decreasing the likelihood of returning to their home country. This interplay of factors has been documented in research by Norredam et al. (2015) and Khlat and Darmon (2003).

Finally, comparisons of mortality between immigrants and non-immigrants may be affected by a process of convergence (Beiser, 2005) related to duration of residence. While recent immigrants in Canada are generally healthier than the Canadian-born population, exposure to the physical, social, and cultural environment of the destination country may diminish the health advantage of recent immigrants (Beiser, 2005; Ng, E. et al., 2005; Ng, E. et al., 2011).

Research on the health and mortality of interprovincial migrants is still limited. Both international and interprovincial migration are affected by various factors related to migration (Wingate & Alexander, 2006; McKay et al., 2003), such as expectations of higher income mobility, employment opportunities, and social well-being. Although internal migrants may need

to adjust to a new province or territory, they usually do not face many of the challenges that international migrants encounter, such as difficulties with social integration into the local culture, networking issues, cultural and political differences, educational gaps, obstacles to accessing employment and health services, and overall integration challenges. Building on the selective migration hypothesis, we hypothesize that both immigrants and interprovincial migrants will have a lower risk of mortality compared to non-migrants.

We further expect that the size of this mortality advantage will vary depending on the level of migration selection, with a larger protective effect among international immigrants than among interprovincial migrants, reflecting the stronger selection processes associated with international migration. A secondary aim is to assess mortality risk among migrant populations, including immigrants, based on their immigration characteristics such as refugee status, secondary migration status, and region of origin, as well as among interprovincial migrants according to their province of origin.

1.2 Theory of the healthy migrant effect

The relatively good health of immigrants from source countries to host countries, known as the ‘healthy immigrant effect’, is widely studied in public health. Generally, healthy immigrants are selected through positive self-selection and rigorous screening applied by host countries. Three major explanations (Medical screening and immigration policy, Healthy lifestyle and diet, and Self-selection) for the better health of migrants compared to natives in the host country are evident in the literature. In Canada, immigrants are categorized for admission as economic immigrants, family class, refugees, or others not included in the aforementioned categories.

1.2.1 Medical screening and immigration policy

Medical screening and immigration policies are conducted by host-country authorities before immigration. As a result, host countries assess prospective immigrants' health. This suggests that host countries may prefer wealthier and educated immigrants, based on the assumption that observable socio-economic factors like wealth and education are often linked to better health outcomes.

Immigration policies of the host countries, such as Canada's point system, positively influence the health outcomes of recent immigrants, particularly those who are young, wealthier, skilled, and more educated. Since wealth and education enhance health outcomes, new immigrants often enjoy better health compared to Canadian-born population (Constant et al., 2017). Consequently, unrestricted immigration policies can have negative effects on immigrant health, whereas selective policies implemented by the host country tend to confer health benefits to recent immigrants relative to native populations (Constant et al., 2017). Conversely, entry and integration policies that are not focused on health are significantly associated with poorer health outcomes among immigrants in developed countries (Juarez et al., 2019).

Health assessment-based systemic selection is an important explanation for the initial health advantage of migrants over natives (Lu. C. and Ng. E., 2019). This matters for a host country because health-related costs for new immigrants are a significant public funding and political issue, and immigrants' health status directly impacts the labour market and the overall economy. It is worth noting that an immigrant's health assessment in their home country might not be the primary factor determining their health advantage.

In Canada, the main requirement is that applicants and family members seeking permanent residence must obtain a medical examination report signed by a doctor or panel

physicians in their home country. For a refugee appellant, a border services officer instructs them to complete a medical exam within 30 days. The doctor completes a questionnaire about the refugee claimant's medical history, including information on weight, height, hearing, vision, blood pressure, heart, lungs, limbs, and skin issues. Depending on their age, the doctor may also request a chest X-ray and laboratory tests. After the exam, the doctor sends the medical results to IRCC (IRCC, 2025; IRCC, 2026).

Recent literature reported that the percentage of annual applicants to Canada rejected on health grounds was insignificant (Lu. C. and Ng. E., 2019). Moreover, the Immigration and Refugee Protection Act (IRPA, 2002) exempted certain immigrant classes, such as refugees and selected groups within the family class, from the medical assessment test (Justice Laws, 2001). In recent years, about 27% of potential immigrants were exempted from the excessive demand inadmissibility ground under IRPA (Lu. C. and Ng. E., 2019). It seems unlikely that this selection mechanism can fully explain the health advantage observed among immigrants.

1.2.2 Healthy lifestyle and diet habits

This theory of potential immigrants' positive self-selection suggests that the healthiest individuals will be at an advantage in source countries compared to weaker groups. The explanation of self-preparations and positive lifestyles indicates that diets and healthy behaviors, including better nutrition, increased physical activity, strong family connections, and other social activities in the country of origin, are some of the main factors contributing to the good health of recent immigrants (Constant et al., 2017). Before migrating, immigrants' healthy habits and behaviors in their home country also play a key role in enabling them to live healthier lives than their native counterparts. Such a positive lifestyle involves, among other things, high levels of physical activity and consumption of low-fat or low-calorie freshly cooked diets (Kennedy et al.,

2006), and a post-migration healthy lifestyle combined with the efficiency of the health care system in the host country helps immigrants enjoy 'the best of both worlds' (Powels, 1990; Khlat and Darmon, 2003). Although the mortality rates in most developing countries are higher than those in the host country, in the absence of selection effects, it would be expected that the health indicators among young people in developing countries are better than those in the destination country (Kennedy et al., 2006).

Moreover, the health outcomes of individuals in most of the source countries could be poorer due to manual and/or hazardous workplace environments with short- or long-term health risks (Kennedy et al., 2006). Although it is assumed that immigrants in the host country are likely to enjoy a health advantage over the native population, higher rates of chronic diseases such as stomach cancer and stroke might be linked to childhood deprivation and exposure to poorer or more toxic environmental conditions (Razum and Twardella, 2002). Additionally, the age at the time of migration is a crucial factor. It is widely recognized that first-generation immigrants generally experience lower mortality from unusual health conditions upon arrival in the host country, as these conditions often take many years to develop.

1.2.3 Self-selection

The tendency towards the favourable self-selection of migrants for economic opportunities and a better life suggests a strong positive relationship between an immigrant's income and health status, which is well documented in current literature. This is rooted in the fact that only the healthiest and most ambitious emigrants often decide to move to a new country to explore better labour markets and access improved social security and health services. Evidence shows that unhealthy and weaker individuals are less motivated and interested in relocating and enduring the traumatic experience of acculturation in a new country for

assimilation into a different labour market (Constant et al., 2017). Economic migrants are those who move either within a country or to other countries in pursuit of economic opportunities. They are self-selected for their potential in the labour market and tend to be more courageous, ambitious, entrepreneurial, and forward-thinking (Chiswick, 2000). It is also important to recognize that economic opportunities and labour market success are not necessarily the main reasons for migration (Chiswick, 2000). Involuntary migration does not typically exhibit the healthy attributes associated with voluntary (economic) migration.

1.2.3.1 Human capital theory

At the individual level, in a broad sense, human capital is the intangible aggregate of education/knowledge/training, health condition, skill, experience, intelligence level, and performance capabilities. These qualities comprise transferable wealth for the purpose of economic development, productivity growth, and innovation. This theory asserts that immigrants are self-selected to be both healthy, skilled and wealthy before migration. It explains how educational attainment, experience, skill and health would help increase the productive capacity and efficiency of people by increasing the level of innate abilities (Garibaldi, P.2006).

According to the human capital theory, forward-looking individuals can boost their productivity through higher education, training, and experience. Highly educated immigrants tend to earn more than those with lower educational credentials. It is assumed that the earnings of highly educated immigrants increase substantially over time in Canada. The purpose of IRPA is to maximize the integration of long-term economic migrants into the knowledge-based labour market (Picot et al., 2014). Health status is also a key component of human capital.

Although the human capital variable is measured by schooling in empirical analyses, health status information is also essential for assessing the human capital of the labour force

(Caselli, 2004). This theory helps explain the selection of economic migrants. There is a critical need for immigrants to be highly educated, skilled, curious, younger, promising, and healthy to adapt to the stresses of integration in the host country (Constant et al, 2017). Higher education, combined with a younger age and the relatively lower cost of attained skills in the home country, drives positive self-selection (Jasso et al., 2004).

Economic migrants are positively self-selected based on pre-emigration earnings. The pre-migration income distribution in the home country indicates a higher proportion of immigrants with higher incomes and a lower proportion at lower incomes compared to non-migrants (Brojas et al., 2019). Unobserved characteristics significantly influence migrants' decision-making and play a dominant role in total income, as reflected in the residuals from Mincerian wage regressions (Brojas et al., 2019). The Mincerian wage regression illustrates the relationship between wages and schooling or experience. The residual term of this equation reflects the portion of wages attributable to unobservable characteristics of individuals. Income and educational attainment are positively linked to health, with highly educated individuals typically experiencing better health outcomes than those with less education (Raghupathi and Raghupathi, 2020). Additionally, income positively influences health (Lenhart, 2019). Handler (2018) argued that in developing countries, individuals in the bottom quintile of the income distribution, who have high educational achievement and rising income levels, are motivated to migrate to developed countries.

Pedersen et al. (2006) estimated a linear and negative relationship between GDP and migration; these authors suggest that migration frequency may be lower from countries with higher GDP. Immigrants leaving high-GDP countries tend to settle in wealthy areas in the host country and are often wealthier than the average immigrant and even natives. Another notable

point is that, on average, individuals who migrate generally have higher educational attainment than non-migrants in their home countries (Handler, 2018).

The self-selected immigrants have a health advantage over natives (Riosmena et al., 2017). If immigrants have a high income in their country of origin before migration, they are more likely to have better access to a healthy diet, safe drinking water, sanitation, and higher-quality child and mental health care. They are also less prone to the devastating effects of environmental degradation. Forward-looking individuals are more aware of their health and are willing to take the risk of moving into an unfamiliar labour market to seek better economic opportunities (Farre, 2015; Antecol and Bedard, 2006). Jasso et al. (2004) argued that fewer highly skilled immigrants migrate from countries where the rewards for skills are higher. The healthiest immigrants tend to come from countries with higher GDPs, where labour productivity is greater.

The new lifestyle, habits, and challenges of adapting to a different society and systems in the host country may negatively impact health over time. This explanation aligns with several other theories that will be discussed here.

1.2.4 Convergence hypothesis

One important hypothesis about immigrants' health is that the process of adoption and acculturation leads to a convergence of immigrants' health toward the health status of natives. The convergence hypothesis assumes a linear process of assimilation into the host country's population. Immigrants need to adopt the host country's culture and overcome language barriers to make economic and social progress. Despite immigrants having better health upon arrival, their health deteriorates and converges with that of native people as their length of stay in the host country increases (Namer and Razum, 2018; Constant, 2017; Uitenbroek, D.G., 2015).

Such health convergence does not support improvements in the socioeconomic conditions of immigrants in the host country (Constant, 2014; Jasso, 2004). Poor socioeconomic conditions along with negative assimilation are the main reasons for the decline in migrants' health advantage over time (Palloni and Arias, 2004; Ronelleafitsch and Razum, 2004). Immigrants face multiple challenges initially when trying to integrate into a diverse society due to lack of language proficiency, differing educational credentials, absence of soft skills like technological familiarity, and limited information about organizations and the job market. As the duration of residence increases, immigrants' acculturation also increases, which influences their health risk factors. Therefore, immigrants' health conditions change with variations in socioeconomic status.

Other factors influencing immigrants' health conditions (such as eating habits, physical activities, smoking, drinking, and lifestyle) may change over time in the host country. Different life routines, socio-cultural norms, and dietary habits (Constant, 2017), along with discrimination (Grove and Zwi, 2006), poor working conditions, and employment in more hazardous and physically demanding jobs (Orrenius and Zavodny, 2009), either alone or combined, affect health outcomes. Cardiometabolic risk factors can vary with the length of residence and differ among ethnic groups (Chiu et al., 2012). The convergence of immigrants' health towards the health status of native populations is a natural process (Jasso, 2004). Health decline is inevitable and leaves limited scope for policy to preserve immigrants' health advantages (Neuman, 2014).

1.2.5 Segmented assimilation hypothesis

This hypothesis questions the unidirectional view of the convergence hypothesis and explores the various patterns of adaptation and integration of different ethnic minorities into the social structure and stratification system of the host society. Income and employment levels vary

among immigrant groups and their children depending on multiple pathways of assimilation.

Immigrants' adaptation and health outcomes differ significantly based on their social and economic status in both their home country and the host country's reception (Feliciano, 2005).

Such successful adoption is again linked to pre-migration factors including immigrants' overall status, job experience, skills, human capital, and wealth. The aspirations and motivations of immigrants vary based on these factors. The pattern of assimilation varies according to the human capital that immigrants have acquired from their home country and from the increasing duration of migration in the host country (Portes and Zhou, 1993). The country of origin, educational attainment, experience, and pre-migrant incomes in the home country influence whether immigrants will assimilate into an underclass or middle class in the host country (Portes and Zhou, 1993).

These diverse pathways may prevent many immigrants from integrating well into the host country, which can deteriorate their health as years of migration increase. Despite rigorous health screening processes imposed by the host countries and the generally better health conditions of potential immigrants in source countries, an immigrant's overall health might decline over time. This trend illustrates aspects of 'negative acculturation' due to low utilization of healthcare services, exposure to unhealthy working and living conditions, and other systemic limitations in the host countries (Constant et al., 2017).

Psychological factors can influence immigrants' health in the host country. Immigrants leave behind their families, relatives, and networks in their home country. Middle-aged and older immigrants who have spent several years in the host country may still miss their home country, especially childhood memories. Differences in climate and geographic conditions can negatively affect health (Constant et al., 2014). Traumatic migration experiences among refugees and

asylum-seekers, along with their strong adherence to religious faiths, and socioeconomic disadvantages and discrimination, may impact their ability to adapt to the new environment (Choy et al., 2021). Psychological deterioration is especially observed in immigrants who migrated at an older age (Bordea, 2019).

1.2.6 Cultural framework and assimilation

The cultural framework plays a crucial role in shaping individual health behaviours. Cultural practices influence health outcomes by impacting behaviours and lifestyles, such as smoking, alcohol consumption, eating calorie-dense diets, and engaging in less physical activity, as well as social activities (Hossin, 2020). These practices are closely linked to acculturation theory; immigrants often swiftly adopt the behaviours of their new environment and discontinue their original cultural practices, which can lead to declining health over time (Abraido-Lanza et al., 2005). Acculturation theory has been criticized for its inherent victim-blaming perspective, which tends to shift attention away from the impacts of systemic inequalities, such as access to healthcare and disparities in the labour market (Hossin, 2020; Viruell-Fuentes, 2007).

To summarize, a key argument supported by various explanations is that immigrants are not randomly chosen from the population of the source countries. Instead, they are intentionally selected through a thorough process that emphasizes need-based human capital. This aspect of policy decision-making indicates that immigrants with certain transferable skills are positively selected. The explanations from the aforementioned theories for the health advantage of migrants exclude the influence of medical screening and immigration policies, which tend to favour healthy lifestyle and diet habits, as well as self-selection driven by a healthy lifestyle, significantly contributing to immigrants' health advantage.

1.3 Methods

1.3.1 Data sources

Information on international immigrants was obtained from the Immigration, Refugees and Citizenship Canada (IRCC) Permanent Resident database, which contains the landing records of all legal immigrants to Canada from January 1, 1985, to December 31, 2017. This database also includes socio-demographic and immigration characteristics such as refugee status, country of birth, and knowledge of official languages. The Manitoba Health Insurance Registry (the Registry) was used to identify all Manitoba residents who registered for provincial universal health care coverage between January 1, 1970, and March 31, 2019, some of whom may be international immigrants who settled in other Canadian provinces before 2018 but moved to Manitoba at any time until March 2019. Internal migrants from other provinces were also identified in the Registry from 1985 onwards. Mortality data were obtained from the Registry as well, since death is a key reason for cancellation of health care coverage. The data linkage process is described in Appendix I.1.

1.3.1.1 Ethics approval

The use of the data was approved by the University of Manitoba Health Research Ethics Board (HS22881 (H2019:216)) and reviewed for data privacy, then approved by the Government of Manitoba's Health Information and Privacy Committee (File No. 2019/2020-17).

1.3.2 Study Population

I included Manitoba residents of all ages and migrants who registered in the Registry between January 1, 1985, and March 31, 2014. The starting point was chosen because of data availability and to allow for a maximum follow-up of 34 years until March 2019. Excluding individuals who immigrated after March 31, 2014, ensured a minimum of 5 years of follow-up

until the study's end on March 31, 2019. Temporary residents, including students, work permit holders, and refugee claimants awaiting decisions, could not be included. To estimate the risk of premature mortality, persons aged over 70 years were censored.

1.3.3. Study design

The study carried out a retrospective, population-based, matched-cohort study using data linkage. The linkage of the IRCC Permanent Resident database with the Registry is of high quality, with a linkage rate of 96% (Urquia et al., 2021). Retrospective data enabled an examination of the mortality experience of a large group of immigrants and non-immigrants over three decades. To accurately compare mortality risks among international immigrants, interprovincial migrants, and all other long-term residents of Manitoba, a population-based matched study was performed. To assess mortality risk within international immigrants and interprovincial migrants based on immigration characteristics and the region of origin, respectively, no matching was necessary, and all individuals within each group were included since comparisons were internal to each group.

1.3.3.1 Matching technique

The study employed matching techniques to evaluate the mortality risks among immigrants, interprovincial migrants, and other long-term Manitoba residents. Both immigrants and interprovincial migrants have distinct demographic profiles compared to other Manitobans. Additionally, most of the other Manitobans were born in Manitoba. In many cases, their Manitoba health insurance coverage starts at birth. The duration of residence for all other long-term Manitoba residents in the province is much longer compared to the other groups. Most immigrants and interprovincial migrants arrived as adults.

Therefore, to ensure a fair comparison among the three groups, matching techniques were used. The statistical literature recommends applying matching methods to reduce the influence of confounders when treatment effects vary significantly between groups, and there is a high chance of excluding many treatments or control observations due to noncomparability (Riosmena et al., 2017; Baser, 2007; Rubin, 2001).

The meaningful comparison of mortality according to the type of migrants involved matching international immigrants 1:1 with all other long-term Manitoba residents and interprovincial migrants, as follows: First, international immigrants were carefully matched without replacement to all other long-term Manitoba residents based on birth year, sex, and place of residence at the time of their first registration for health care coverage in Manitoba. Second, because the pool of interprovincial migrants available for matching was smaller, international immigrants were matched without replacement to interprovincial migrants based on a propensity score with a caliper of 0.01. The propensity score was estimated using a logistic model that predicted the likelihood of being an international immigrant or an interprovincial migrant based on age, sex, place of first residence in Manitoba, and date of migration to Manitoba (within 5 years). Since the same international immigrant was matched to one all other Manitobans and one interprovincial migrant, the three formed a matching triad. The adequacy of the matching was considered satisfactory based on comparisons of sociodemographic variables, with standardized differences consistently below 10% (Appendix I.2 and I.3).

1.3.3.2 Variable definitions

1.3.3.2.1 Outcome Variables

We studied all-cause mortality and premature mortality (deaths up until age 70). The outcome variable was death between January 1985 and March 2019.

1.3.3.2.2 Comparison groups

International immigrants were all Manitoba residents with a landing record in the IRCC's Permanent Resident database. International migrants were further subclassified as refugees, not refugees, primary immigrants (who migrated from their country of origin) and secondary immigrants (who migrated from a country other than their country of birth) (Urquia et al., 2010; Wanigaratne et al., 2016).

Interprovincial migrants were those who moved to Manitoba from other Canadian provinces and were not born outside Canada. The overall group of long-term Manitoba residents, which serves as the reference group, includes individuals who registered for the provincial public healthcare insurance from birth because they were born in Manitoba after 1970, as well as those who lived in Manitoba prior to the creation of the Registry in 1970.

1.3.3.2.3 Socio-demographic Characteristics

Socio-demographic characteristics for the entire population were solely obtained from the Registry and included year of first registration for health coverage, age, sex, relationship status, and place of residence. Place of residence was used to determine rural status and neighbourhood income quintiles based on Canadian censuses at the dissemination area level, which is the smallest geographic unit for census data aggregation. Income quintiles were derived from the average household income according to the Canada Census for the entire MB population (all ages), ensuring that 20% of the population falls into each quintile. These quintiles are calculated separately for the urban population in Manitoba (Winnipeg & Brandon) and for the rural areas (the rest of the province). The Registry also recorded the province of origin for internal migrants. Variables specific to international immigrants were obtained from the IRCC Permanent Resident database, including marital status at arrival, educational attainment, refugee status, country of

Table 1.1: Definitions of dependent and independent variables

Variable	Type	Definition
Survival time	Continuous	The dependent variable is the waiting time from January 1985 till the occurrence of death to March 31, 2019
Migration status	Categorical	International immigrants: Individuals born outside Canada. Interprovincial migrants: Individuals born in other Canadian provinces who migrated to Manitoba. All other long-term Manitoba residents/all other Manitobans): Manitoba residents who were born in Manitoba or who resided in Manitoba before creating the registry in 1970 as base category.
Year of the start of the follow-up	Categorical	The year of the start of the follow-up is categorized based on the date of coverage started. All other long-term Manitoba residents. All were assigned the same date of start of follow-up as the date coverage began for immigrant matches. Year group 1985-1994 is the base category.
Age at start of follow-up	Continuous	This variable presents the age of all individuals among the three groups at the start of coverage. The start of coverage of all other long-term Manitoba residents matched with international immigrants.
Sex	Binary	Male; Female (base category)
Marital status	Binary (Matched study and interprovincial migrants' cohort) Categorical (Immigrant cohort)	Married/Common-Law Partner, Single (base category) In the immigrant study, the categories are Single never married Married/Common-law (base category) Divorced/separated/widowed Unknown
Neighbourhood income level	Categorical	Individual income levels are measured by the average neighbourhood household income in which they live, across five urban and five rural areas. The Income ranges of the neighbourhood 1 st quintile, 2 nd quintile, 3 rd quintile, 4 th quintile, 5 th quintile (base category), Quintile N/A
Rural residence	Binary	Rural residence, urban residence (base category)
Refugee	Binary	Refugees are migrants who have fled due to war, violence, conflict or persecution and seek asylum. Refugee, not refugee (base category)
Secondary immigrant	Binary	Secondary immigrants are those who migrated from a country other than their country of origin. Primary immigrants are those who migrated directly to Canada from their country of origin.

Variable	Type	Definition
		Levels: Secondary immigrant, primary immigrant (base category)
Educational attainment	Categorical	The variable represents immigrants' educational qualifications as reported in their permanent residence applications. Secondary or less, Trade/certificate/post-secondary, University degree (base category), Unknown
Knowledge of English and/or French	Binary	Yes/no knowledge of English or French (base category)
World region of origin	Categorical	The variable represents the source country of immigrants. Southeast Asia, South Asia, Rest of Asia, East Europe, Rest of Europe (base category), North Africa, East Africa, Rest of Africa, North America and Oceania, Latin America and the Caribbean
Province of origin	Categorical	The variable represents the Provinces of Canada from which the interprovincial migrants migrated to Manitoba. Alberta, British Columbia, Ontario (base category), Saskatchewan, Quebec, Atlantic Canada (Nova Scotia, New Brunswick, Prince Edward Island), Arctic (Northwestern Territories, Yukon)

birth, and last permanent residence. The two groups of migrants were categorized by decades of arrival and age at the start of follow-up, which included Manitobans matched to them. The definitions of these variables are provided in Table 1.1.

1.3.4 Data analysis

Survival time was defined as the period from immigration to Manitoba to death, or to censorship due to moving out of province (i.e., the cancellation of healthcare coverage), or to the end of the study period for immigrants, expressed as person-years. The survival time in this study spans from January 1985 to March 31, 2019. For all other long-term Manitoba residents, the study used the arrival date of their matched immigrants as the starting point for follow-up. The mortality rate is a straightforward measure of deaths per 1000 person-years. It represents the ratio of total deaths to total person-years of follow-up within a group over a specific period, multiplied by 1000 to estimate the number of deaths per 1000 person-years.

1.3.4.1 Poisson regression

For the analysis comparing the mortality risk of international immigrants and interprovincial migrants with that of non-migrants, the study used conditional Poisson regression, which accounts for matching between the comparison groups by age, sex, and region of residence at the time of arrival in Manitoba. The Poisson and Cox regression models can be used in survival analysis and produce results that are nearly identical (Edward et al., 2000). The mean (4.046) and variance (4.044) of the death counts are almost equal in the dataset, and the survival times follow an approximately exponential distribution, as shown in Figure 1.1. The Poisson and Cox regressions produce nearly identical results and may provide narrower confidence intervals in Poisson regression (Yang et al., 2017).

This study employed conditional Poisson regression, which accounts for matching between comparison groups by age, sex, and region of residence at the time of arrival in Manitoba. It examines the linear relationship between time-to-event risk and migration status through a generalized linear model using a Poisson distribution (Dobson and Barnett, 2018). The Poisson regression models assessed the association between migration status and all-cause and premature mortality, expressed as incidence rate ratios.

To address the differences in follow-up time among individuals, this analysis included an offset term for follow-up duration. Poisson regression used the logarithm of person-years as an offset variable to account for different follow-up periods, evaluating the relationship between migrant status and both all-cause and premature mortality, presented as incidence rate ratios. The models further adjusted for the year when health care coverage started, relationship status, neighbourhood income quintile, and whether the residence was rural or urban.

1.3.4.2 The Cox regression

The study also estimates the extended Cox model with time interaction to compare mortality risk among international immigrants, interprovincial migrants, and all other long-term Manitoba residents over time using person-years. The Cox model examines the relationship between survival time and explanatory variables (Hosmer et al., 2008). For a continuous outcome, linear regression may be employed. If the outcome is binary, such as whether a patient has diabetes, logistic regression is appropriate. However, when the outcome is survival time, survival analysis is a common statistical method (George et al., 2014; Hosmer et al., 2008). For instance, in the migrant mortality risk study, a sufficiently long follow-up would result in equal survival rates of 0% across groups. In such cases, survival time provides much more meaningful statistical information than simply whether the event occurred or not (George et al., 2014).

The focus of this study is the occurrence of death. Individuals who did not die before March 31, 2019, or who dropped out before the study ended will be censored in the survival analysis. Although cases that dropped out earlier are similar to missing data in any regression analysis, survival analysis can handle observations that did not experience the event before the study concluded (George et al., 2014). The analysis uses censored data to estimate the impact of socio-economic factors on survival time.

Therefore, when the outcome is the time to the event, and there is a long follow-up, survival analysis generally has greater statistical power than models with a binary outcome, such as logit regression (George et al., 2014; Callas et al., 1998). Regression analysis aims to identify the significant effects of predictor variables on the outcome. Survival analysis estimates the effects of covariates and the interaction between two predictors on survival time (George et al.,

2014). The time-to-event data are skewed (Schober and Vetter, 2018), and the model must account for censoring.

Therefore, the OLS (Ordinary Least Squares) regression model cannot be used because it assumes normality (Gujarati, 2003). Based on Hosmer et al. (2008), the Cox model is discussed below. The cumulative density function of T represents the probability that a randomly selected subject has T less than or equal to the stated value t (time horizon), which is denoted

$$\text{as } F(t) = \Pr(T \leq t)$$

The survival function is $S(t) = 1 - F(t)$

The hazard function describes the instantaneous risk of death over a narrow time interval.

The hazard function is $h(t) = \frac{f(t)}{S(t)}$

It represents the risks or hazards at each time interval that an individual will not survive to the next. The cumulative hazard function from time 0 to t is $H(t) = \int_0^t h(u)du$

If the time variable is continuous, then the survival function can be represented as $S(t) = e^{-H(t)}$

The hazard function is a rate that can be described as $h(t) = \theta_0$

The Cox model shows the relationship between predictors and the hazard rate ($h(t)$). Here $h(t)$ represents the probability of dying during time t, where $\beta_0 = \ln(\theta_0)$. For a covariate x, the hazard function is $h(t, X) = e^{\beta_0 + \beta_1 X}$. The hazard ratio (HR) function for two persons is

$$HR(t, X_0, X_1) = \frac{h_0(t) r(X_1, \beta)}{h_0(t) r(X_0, \beta)}$$

The proportional hazards model assumes that the hazard ratio remains constant over time. This is the most popular survival regression model for assessing the association between time to death and predictors. Cox (1972) first introduced this analysis. The hazard function is

$$h(t|X) = h_0(t)e^{X\beta}$$

The hazard function can be expressed as $\frac{h(t|X)}{h_0(t)} = e^{X\beta}$

or as the logarithmic expression is $\log \left[\frac{h(t|X)}{h_0(t)} \right] = X\beta$

The hazard ratio helps interpret estimates from the proportional hazards model. A higher HR (greater than one) indicates an increased risk of death, while a lower HR (less than one) suggests a decreased risk. When HR equals 1, the predictor has no effect (Hosmer et al., 2008; George et al., 2014).

The survival probability over the years of follow-up in Figure 1.1 can be used to evaluate the main assumption of the Cox proportional hazards model. The survival curves of international immigrants, interprovincial migrants, and all other long-term Manitoba residents do not cross at any point during follow-up. These curves suggest that the hazards are approximately proportional in the large administrative dataset. Since the curve is curvilinear, I also estimated the piecewise Cox regression model (with interaction) to compare the overall follow-up mortality risk and how it changes over time among international immigrants, interprovincial migrants, and all other long-term Manitoba residents.

1.3.4.3 Survival Curve (Kaplan-Meier Curve)

The survival curve illustrates the probability that an individual remains alive over time. This descriptive measure helps compare survival probabilities between groups (Barakat et al.,

2019; Etikan et al., 2017; Goel et al., 2010). In this study, the Kaplan-Meier curve was used to depict the mortality experiences of the comparison groups.

1.3.4.4. Inverse Probability of Censoring Weight (IPCW)

Additionally, the study employed inverse probability of censoring weights in the regression analysis to address the salmon bias, following the recommendations of Howe et al. (2016). This bias might occur from loss to follow-up among immigrants and the possibility that they may pass away in their home countries (Valles, 2016; Abraido-Lanza et al., 1999). The study identifies return international immigrants through the cancellation code in the Manitoba health insurance registry, focusing on individuals who have cancelled their Manitoba health care coverage and moved to the USA or other countries, excluding Canadian provinces or territories. It also includes those whose destinations are unknown or who have left Manitoba without a certificate. As follows, Howe, C et al., 2016.

The study employed a pooled logistic regression model where age at the start of follow-up was modeled in both linear and quadratic forms, along with sex, region of origin, and the year of landing in Canada. The mean and variance of the stabilized IPCW were 1.02 and 0.02, respectively, with a range from 0.83 to 2.55. This IPCW was used as a weight in the analysis to adjust for salmon bias and to compare mortality risk between immigrants and non-immigrants.

In analyses limited to international and interprovincial migrants, respectively, which focused on heterogeneity in mortality risk across various immigration characteristics within each group, no matching was required because the comparisons were internal to immigrants; instead, unconditioned Poisson models were employed. All analyses were performed using SAS 9.4 (SAS Institute, Cary, North Carolina, USA).

1.4 Results

1.4.1 Description of the final sample sizes

There were 263,711 international immigrants. Of these, 55,745 were excluded if they arrived on or after April 1, 2014, to allow for a minimum of five years of follow-up. The study also excluded 552 immigrants with invalid postal code information. The final sample size for this group was 207,414. There were 278,289 interprovincial migrants whose healthcare coverage started between 1985 and 2017. After excluding 24,661 individuals who did not have an international immigrant match arriving after April 2014 and 1336 individuals with invalid postal code information, the final sample size for interprovincial migrants was 252,292. In the registry, there were 727,341 all other long-term Manitoba residents whose coverage started before 1970, and 692,515 born in the province since then, for a total of 1,419,856 Manitobans. For all other long-term Manitoba residents, the same follow-up start date from January 1, 1985, and exclusion of observations after April 1, 2014, were used. After matching on birth year, Sex, and place of residence at the year of start of follow-up, the ratio of Immigrants and interprovincial migrants to all other long-term Manitoba residents was 1. The final sample sizes for the matched analyses included 355,194 individuals (118,398 in each comparison group).

The characteristics of international migrants (118,398) in the matched cohort and all international migrants in the final sample (207,414) without matching are similar. Most international migrants arrived in Manitoba between 1995 and 2014 (66.5% in the matched cohort and 79.3% in the full sample). Most international migrants (85.9% in the matched cohort and 87.3% in the full sample) arrived in Manitoba at a young age (0-44 years). Among international migrants, 81.5% of the matched cohort and 85.2% of the full sample lived in urban areas. Furthermore, within the international migrant group, 77.07% of the matched cohort and 81.54%

of the full sample resided in the Winnipeg Regional Health Authority region. Notably, 19% of the matched cohort and 16% of the full sample identified as refugees. Additionally, approximately 54% of international migrants in the matched cohort and 58% in the full sample had knowledge of English and/or French at immigration. Finally, 52% of the matched cohort and 60% of the full sample arrived in Manitoba from Asia.

1.4.1.1 Characteristics of the matched study population

Table 1.2 shows the characteristics of the three groups. There were almost no differences between the groups regarding the matching variables, year of start of follow-up, age groups, and sex. The largest proportion of individuals among immigrants (33.6%), interprovincial migrants (26.4%), and all other long-term Manitoba residents (32.9%) remained in the lowest income quintile (Quintile 1).

Among international migrants, 37.8% had a spouse, compared to 27.2% among interprovincial migrants and 22.7% among all other long-term Manitoba residents. In the matched dataset of immigrants, 18.85% were refugees and 13.84% were secondary immigrants. Additionally, about 20% held a university degree, while 45% had a secondary or lower educational credential. Moreover, 54% of international immigrants possessed English and/or French language skills at the time of their immigration. Most international immigrants came from Asia (52%), followed by Europe (23.7%). Most interprovincial migrants to Manitoba originated from Ontario (36.6%) and Alberta (21.0%), with others arriving from British Columbia (15.7%) and Saskatchewan (14.6%).

Table 1.2 Characteristics of the matched study population at the start of the follow up

	International Immigrants N (%)	Interprovincial Migrants N (%)	All other long- term Manitoba residents N (%)
Total Population	118,398	118,398	118,398
Year of start of the follow-up			
1985-1994	39,656 (33.5)	36432 (30.8)	39,656(33.5)
1995-2004	36,585 (30.9)	32,533 (27.5)	36,585 (30.9)
2005-2014	42,157 (35.6)	49,433 (41.7)	42,157 (35.6)
Age Groups at start of follow-up			
0-14	31,382 (26.5)	31,930 (26.9)	31,442 (26.6)
15-24	22,738 (19.2)	21,794 (18.4)	22,714 (19.2)
25-44	47,651 (40.2)	47,917 (40.5)	47,573 (40.2)
45-64	13,026 (11.0)	12,960 (10.9)	13,069 (11.0)
65-84	3497 (2.9)	3207 (2.7)	3496 (2.9)
85 and above	104 (0.08)	590 (0.5)	104 (0.08)
Male Sex	60,484 (51.1)	60,331 (51.0)	60,484 (51.1)
Relationship Status: Has spouse	44,960 (37.9)	32,217 (27.2)	26,844 (22.7)
Neighborhood Income Level			
Quintile 1	39,733 (33.6)	31,323 (26.4)	38,938 (32.9)
Quintile 2	24,116 (20.4)	22,513 (19.0)	21,678 (18.3)
Quintile 3	20,161 (17.0)	21,501 (18.1)	21,838 (18.4)
Quintile 4	17,739 (14.9)	20,009 (16.8)	17,452 (14.7)
Quintile 5	15,967 (13.5)	22,286 (18.8)	15,553 (13.1)
Quintile N/A	682 (0.6)	766 (0.6)	2939 (2.5)
Rural Residence	21,909 (18.5)	24,348 (20.5)	21,909 (18.5)
Refugee Status			
Yes	22323 (18.85)		
No	96075 (81.15)		
Secondary migration			
Yes	15610 (13.84)		
No	102788 (86.82)		
Marital status			
Single never married	61320 (51.79)		
Married/Common law	52935 (44.71)		
Divorced/separated/widowed	3284 (2.77)		
Unknown	859 (0.73)		
Educational attainment			
Secondary or less	54096 (45.69)		
Some post- secondary/Trade/Certificate	20381 (17.21)		
University degree (reference)	23503 (19.85)		
Unknown	20418 (17.25)		

	International Immigrants N (%)	Interprovincial Migrants N (%)	All other long- term Manitoba residents N (%)
Total Population	118,398	118,398	118,398
Knowledge of English and/or French	63862 (53.94)		
No knowledge of English and/or French	54536 (46.06)		
World region of origin			
Southeast Asia	28137 (23.8)		
South Asia	13077 (11.0)		
Rest of Asia	20413 (17.2)		
East Europe	11806 (10.0)		
Rest of Europe	16231 (13.7)		
North Africa	2395 (2.0)		
East Africa	5699 (4.8)		
Rest of Africa	4476 (3.8)		
North America & Oceania	4450 (3.8)		
Latin America & Caribbean	11678 (9.9)		
Unknown Region of Birth	36 (0.03)		
<i>Province of Origin</i>			
Manitoba			118,398 (100)
British Columbia		18640 (15.7)	
Alberta		24838 (21.0)	
Saskatchewan		17303 (14.6)	
Ontario		43373 (36.6)	
Quebec		5098 (4.3)	
Atlantic Canada (NB, NS, PE)		7901 (6.7)	
Arctic (NT, YK, NU)		1245 (1.1)	

Table 1.3 displays person-years and crude all-cause and premature mortality rates for the three groups. There is an increasing gradient in crude all-cause and premature mortality rates per 1000 person-years from international immigrants (2.3 and 1.03) to interprovincial migrants (4.4 and 2.15) to all other long-term Manitoba residents (5.6 and 3.41). The crude mortality rates are higher among individuals with a start of follow-up in 1985-1994, with international immigrants (3.47), interprovincial migrants (4.62), and all other long-term Manitoba residents (7.75) exhibiting higher rates than those in 1995-2004 and 2005-2014.

Table 1.3: Person years and crude mortality rates (per 1000 person-years) for all-cause mortality among matched international Migrants (N=118,398), Interprovincial Migrants (N=118,398), and all other Manitobans (N=118,398)

	International Immigrants (N =118,398)		Interprovincial Migrants (N =118,398)		Long-term Manitobans (N =118,398)	
	Person-years (No of Deaths /Column percent)	Rate	Person-years (No of Deaths)	Rate	Person-years (No of Deaths)	Rate
All-cause mortality	1,385,664 (3184)	2.30	915,298 (4011)	4.38	1,654,872 (9215)	5.57
Premature mortality	1,326,823 (1363)	1.03	882,754 (1905)	2.16	1,581,687 (5396)	3.41
Year starts of follow-up						
1985-1994	627,736 (45.3)	3.47	388,328 (42.4)	4.62	762,328 (46.1)	7.75
1995-2004	431,999 (31.2)	1.67	281,165 (30.7)	4.33	524,574 (31.7)	4.54
2005-2014	325,928 (23.5)	0.87	245,806 (26.8)	4.06	367,971 (22.2)	2.51
Age at start of follow-up						
0-14	377,816 (27.3)	0.23	265,319 (29.0)	0.33	422,284 (25.5)	0.83
15-24	271,809 (19.6)	0.39	144,436 (15.8)	0.71	288,331 (17.4)	2.02
25-44	549,157 (39.6)	1.18	380,806 (41.6)	2.36	709,895 (42.9)	3.77
45-64	150,006 (10.8)	7.84	100,970 (11.0)	12.2	193,730 (11.7)	16.7
65-84	36,301 (2.6)	29.83	21,506 (2.3)	59.5	40,152 (2.4)	56.7
85 and above	572 (0.04)	144.9	2,259 (0.2)	181	478 (0.03)	206
Male	695,173 (50.17)	2.35	454,600 (49.67)	4.67	822,291 (49.69)	5.98
Female	690,492 (49.83)	2.25	460,699 (50.33)	4.10	832,582 (50.31)	5.16
Relationship: Has spouse	518,125 (37.39)	3.22	277,268 (30.29)	5.23	456,282 (27.57)	8.37
Relationship: Has no spouse	867,539 (62.61)	1.75	638,031 (69.71)	4.01	1,198,591 (72.43)	4.50
Neighborhood Income Quintile 1	466,252 (33.65)	2.20	222,603 (24.32)	5.24	555,204 (33.55)	7.11
Quintile 2	287,532 (19.62)	2.29	179,553 (19.62)	4.57	296,698 (17.93)	4.74
Quintile 3	233,384 (16.84)	2.13	165,801 (18.11)	4.36	304,934 (18.43)	4.50
Quintile 4	219, 272 (15.82)	2.44	163,660 (17.88)	3.53	246,540 (14.90)	3.93
Quintile 5	172,054 (12.42)	2.63	178,489 (19.50)	3.40	206,503 (12.48)	3.99
Quintile N/A	7171 (0.52)	2.79	5193 (0.57)	22.3	44,993 (2.72)	15.4
Rural Residence	229,342 (16.55)	1.71	176,725 (19.31)	3.70	298,610 (18.04)	3.12
Urban Residence	1,156,323 (83.45)	2.41	738,574 (80.69)	4.55	1,356,263 (81.96)	6.11
Refugee Status						
Yes	260,882 (18.83)	1.55				
No	1,124,783 (81.17)	2.47				
Secondary migration						
Yes	154,426 (11.14)	3.09				
No	1,231,238 (88.86)	2.20				
Marital status						
Single never married	727,764 (52.52)	0.58				

Married/Common law	608,711 (43.93)	3.16				
Div./sep./wid	37,189 (2.68)	20.36				
Unknown	12,000 (0.87)	6.75				
Educational attainment						
Secondary or less	677,552 (48.90)	2.87				
Some post-Secondary	244,250 (17.63)	2.05				
University degree	237,544 (17.14)	1.60				
Unknown	226,319 (16.33)	1.60				
Language Proficiency						
English and/or French (Yes)	718,495 (51.85)	2.24				
No	667,170 (48.15)	2.35				
World region of origin						
Southeast Asia	403,278 (29.10)	2.63				
South Asia	132,031 (9.53)	2.33				
Rest of Asia	177,953 (12.84)	1.96				
East Europe	145083 (10.47)	2.65				
Rest of Europe	204324 (14.75)	2.33				
North Africa	20,119 (1.45)	1.34				
East Africa	52,045 (3.76)	1.21				
Rest of Africa	42,191 (3.04)	1.16				
North America & Oceania	47,644 (3.44)	4.05				
Latin America & Caribbean	160,594 (11.59)	1.71				
Unknown Region of Birth	403 (0.03)	2.48				
<i>Province of Origin</i>						
Manitoba					1654872 (100)	5.57
British Columbia			140,919 (15.4)	5.96		
Alberta			203,271 (22.21)	3.66		
Saskatchewan			149,465 (16.33)	4.15		
Ontario (référence)			320,921 (35.06)	4.53		
Quebec			35,567 (3.89)	4.67		
Atlantic (NB,NS,PE)			53,387 (5.83)	2.73		
Artic (NT, YK, NU)			11,769 (1.29)	3.31		

* Death rates expressed per 1000 individuals. Except for the first two rows, the mortality rates were presented for all causes.

The crude mortality risk is higher among individuals with a spouse, with international immigrants (3.22), interprovincial migrants (5.23), and all other long-term Manitoba residents (8.37) reporting higher rates than those without a spouse.

Among immigrants, the crude mortality rates are higher among refugees (2.47) than non-refugees (1.55), secondary migrants (3.09) than primary migrants (2.20), and those who immigrated from North America and Oceania (4.05) than others. Among the interprovincial migrants, those who migrated from British Columbia (5.96) had a higher mortality risk than those who migrated from other provinces or territories.

1.4.2 All-cause mortality and premature mortality rates

Table 1.4 compares the IRR and aIRR for all-cause and premature mortality risks among international immigrants, interprovincial migrants, and all other long-term Manitoba residents using Poisson regression. Compared to all other long-term Manitoba residents, the adjusted risk of death for international immigrants was significantly lower than that of Manitobans (aIRR: 0.43; 95% CI: 0.42, 0.45 for all-cause mortality and aIRR: 0.35; 95% CI: 0.33, 0.37 for premature mortality). Similarly, interprovincial migrants had a lower likelihood of experiencing all-cause and premature mortality compared to Manitobans (aIRR: 0.82; 95% CI: 0.79, 0.85 and aIRR: 0.70; 95% CI: 0.66, 0.74, respectively).

The rates of all-cause and premature mortality among international immigrants were notably lower than those of interprovincial migrants (aIRR: 0.54; 95% CI: 0.51, 0.56 and 0.49; 95% CI: 0.46, 0.53, respectively). The aIRR estimates comparing international immigrants to Manitobans (aIRR: 0.44; 95% CI: 0.43, 0.46 for all-cause mortality and aIRR: 0.35; 95% CI: 0.33, 0.37 for premature mortality), and international immigrants to interprovincial migrants (aIRR: 0.54; 95% CI: 0.52, 0.57 for all-cause mortality and aIRR: 0.50; 95% CI: 0.47, 0.54 for premature mortality) remained nearly unchanged after adjusting for potential censoring through the inverse probability of censoring weights in the model. This indicates that bias from selective

out-migration (salmon bias) is minimal. The mortality advantage of international migrants compared to Manitobans and interprovincial migrants was consistent regardless of sex.

The analysis in Table 1.5, stratified by the start of the follow-up period (1985-1994, 1995-2004, and 2005-2014), shows that international immigrants had a lower mortality risk than other Manitobans, regardless of the year of the start of the follow-up period. For individuals whose follow-up started between 1985 and 1994, the aIRR were 0.45 (95% CI: 0.43, 0.47) for all-cause mortality and 0.37 (95% CI: 0.34, 0.40) for premature mortality. Similarly, for those whose follow-up began from 2004 to 2014, the aIRRs were 0.39 (95% CI: 0.34, 0.44) for all-cause mortality and 0.33 (95% CI: 0.28, 0.39) for premature mortality, reinforcing the finding that international immigrants had lower mortality rates than Manitobans. The mortality advantage of international migrants over interprovincial migrants was observed at the start of all follow-up periods.

The survival analysis with the interaction of person years in Table 1.6 shows that immigrants had substantially lower mortality risk than Manitobans, with adjusted hazard ratios (aHR) of 0.32 (95% CI: 0.29–0.35), 0.53 (0.45–0.61), and 0.49 (0.43–0.56) for follow-up periods of 0–10, 11–20, and ≥ 21 years, respectively. It indicates that the immigrant mortality advantage was strongest during the first 10 years of follow-up, was attenuated during 11–20 years, and remained relatively stable thereafter, suggesting partial convergence of mortality risks over time.

The Kaplan-Meier curves in Figure 1.1 demonstrate that the survival advantage of international immigrants was apparent over time following migration. The downward curved pattern of the curves for all three groups, more noticeable for all-cause mortality in Figure 1.1, shows an increasing risk of death, which rises with age and time since migration.

Table 1.4: Unadjusted and adjusted all-cause and premature mortality among international migrants, interprovincial migrants, and all other long-term Manitoba residents

	All-Cause Mortality			Premature Mortality		
	IRR (95% CI)	AIRR*** (95% CI)	wAIRR** (95% CI)	IRR (95% CI)	AIRR*** (95% CI)	wAIRR** (95% CI)
Immigrants vs. All other Manitobans	0.40 (0.38, 0.41)	0.43 (0.42, 0.45)	0.44 (0.43, 0.46)	0.30 (0.28, 0.32)	0.35 (0.33, 0.37)	0.35 (0.33, 0.37)
Interprovincial Migrants vs. All other Manitobans	0.77 (0.74, 0.80)	0.81 (0.80, 0.84)	0.82 (0.79, 0.85)	0.63 (0.61, 0.66)	0.70 (0.66, 0.74)	0.71 (0.67, 0.74)
Immigrants vs. Interprovincial Migrants	0.52 (0.49, 0.54)	0.53 (0.50, 0.55)	0.54 (0.52, 0.57)	0.47 (0.44, 0.51)	0.49 (0.46, 0.53)	0.50 (0.47, 0.54)
Male						
Immigrants vs. All other Manitobans	0.37 (0.35, 0.39)	0.41 (0.39, 0.43)	0.42 (0.40, 0.44)	0.31 (0.29, 0.33)	0.36 (0.33, 0.39)	0.36 (0.33, 0.39)
Interprovincial Migrants vs. All other Manitobans	0.77 (0.73, 0.81)	0.80 (0.76, 0.83)	0.80 (0.76, 0.83)	0.66 (0.62, 0.70)	0.70 (0.66, 0.75)	0.70 (0.66, 0.75)
Immigrants vs. Interprovincial Migrants	0.48 (0.45, 0.52)	0.52 (0.49, 0.55)	0.53 (0.50, 0.56)	0.47 (0.43, 0.51)	0.52 (0.47, 0.56)	0.52 (0.47, 0.56)
Female						
Immigrants vs. All other Manitobans	0.41 (0.39, 0.44)	0.45 (0.43, 0.48)	0.47 (0.44, 0.49)	0.28 (0.25, 0.31)	0.32 (0.29, 0.36)	0.33 (0.30, 0.37)
Interprovincial Migrants vs. All other Manitobans	0.79 (0.74, 0.83)	0.81 (0.77, 0.85)	0.81 (0.77, 0.85)	0.59 (0.54, 0.64)	0.69 (0.64, 0.75)	0.69 (0.64, 0.75)
Immigrants vs. Interprovincial Migrants	0.53 (0.49, 0.55)	0.56 (0.53, 0.59)	0.58 (0.54, 0.61)	0.47 (0.42, 0.53)	0.47 (0.42, 0.53)	0.48 (0.43, 0.54)

Abbreviations: IRR: Incidence rate ratio; AIRR: Adjusted incidence rate ratio; CI: Confidence intervals

1:1 Matching based on sex, age at the start of follow-up, and place of residence at the start of follow-up

Estimates obtained with conditional Poisson regression with person-years as an offset variable

*** Adjusted for relationship status, neighbourhood income quintile and rural residence

** wAIRR is adjusted IRR using inverse probability weight and adjusted for relationship status, neighbourhood income quintile and rural residence.

Table 1.5: Unadjusted and adjusted incidence rate ratios for all-cause and premature mortality among matched International Migrants (N=118,398), Interprovincial Migrants (N=118,398), and all other long-term Manitoba residents(N=118,398), by period of start of follow-up

Start of follow-up	All-Cause Mortality		Premature Mortality	
	IRR (95% CI)	AIRR ^a (95% CI)	IRR (95% CI)	AIRR ^a (95% CI)
1985-1994				
Immigrants vs. All other Manitobans	0.42 (0.40, 0.44)	0.45 (0.43, 0.47)	0.33 (0.31, 0.36)	0.37 (0.34, 0.40)
Interprovincial Migrants vs. All other Manitobans	0.58 (0.55, 0.61)	0.76 (0.73, 0.80)	0.62 (0.57, 0.66)	0.69 (0.64, 0.74)
Immigrants vs. Interprovincial Migrants	0.73 (0.68, 0.78)	0.60 (0.56, 0.62)	0.54 (0.49, 0.59)	0.54 (0.49, 0.59)
1995-2004				
Immigrants vs. all other Manitobans	0.35 (0.32, 0.38)	0.40 (0.37, 0.44)	0.25 (0.22, 0.28)	0.30 (0.27, 0.34)
Interprovincial Migrants vs. all other Manitobans	0.95 (0.89, 1.02)	0.77 (0.72, 0.82)	0.65 (0.59, 0.72)	0.69 (0.63, 0.76)
Immigrants vs. Interprovincial Migrants	0.36 (0.33, 0.40)	0.52 (0.48, 0.58)	0.38 (0.34, 0.44)	0.44 (0.39, 0.51)
2005-2014				
Immigrants vs. all other Manitobans	0.33 (0.29, 0.38)	0.39 (0.34, 0.44)	0.26 (0.22, 0.31)	0.33 (0.28, 0.39)
Interprovincial Migrants vs. all other Manitobans	1.62 (1.47, 1.77)	0.83 (0.76, 0.91)	0.72 (0.64, 0.83)	0.68 (0.59, 0.77)
Immigrants vs. Interprovincial Migrants	0.21 (0.18, 0.24)	0.46 (0.41, 0.53)	0.36 (0.30, 0.44)	0.49 (0.40, 0.59)

Abbreviations: IRR: Incidence Rate Ratio; AIRR: Adjusted Incidence Rate Ratio; CI: Confidence Intervals.

1:1 matching based on sex, age at start of follow-up and place of residence at start of follow-up.
Estimates obtained with Conditional Poisson regression with person-years as an offset variable.

^a Adjusted for relationship status, neighbourhood income quintile and rural residence

Table 1.6: Adjusted hazard ratios for all-cause and premature mortality among international migrants, interprovincial migrants, and all other Manitobans

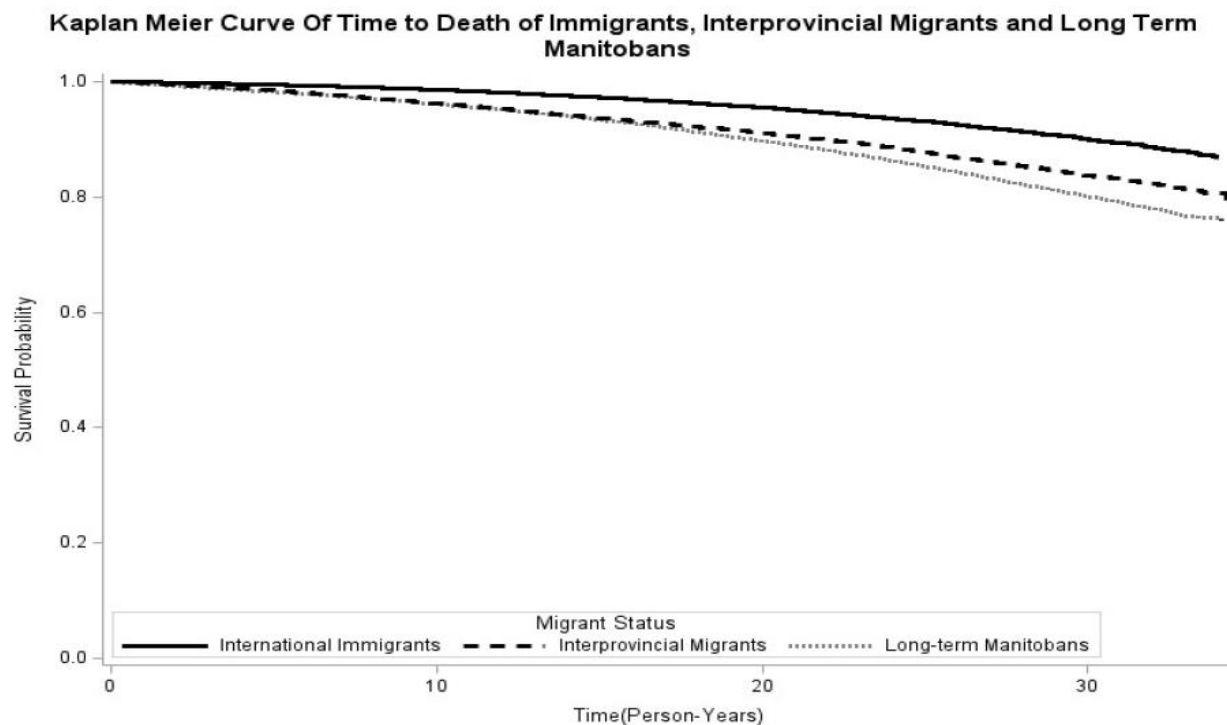
	All-Cause Mortality			Premature Mortality		
	AHR*** (95% CI) (1 -10 person years)	AHR*** (95% CI) (11 – 20 person years)	AHR*** (95% CI) (21 + Person years)	AHR*** (95% CI) (1 -10 Person years)	AHR*** (95% CI) (11 – 20 Person years)	AHR*** (95% CI) (20+ Person years)
Immigrants vs. All other Manitobans	0.32 (0.29, 0.35)	0.53 (0.45, 0.61)	0.49 (0.43, 0.56)	0.22 (0.19, 0.25)	0.40 (0.32, 0.50)	0.41 (0.34, 0.49)
Interprovincial Migrants vs. All other Manitobans	0.62 (0.56, 0.68)	0.79 (0.66, 0.96)	0.75 (0.62, 0.92)	0.34 (0.30, 0.39)	0.67 (0.51, 0.87)	0.89 (0.66, 1.19)
Immigrants vs. Interprovincial Migrants	0.51 (0.46, 0.58)	0.67 (0.54, 0.82)	0.65 (0.53, 0.81)	0.63 (0.54, 0.75)	0.60 (0.44, 0.82)	0.46 (0.34, 0.63)
Male						
Immigrants vs. All other Manitobans	0.27 (0.23, 0.32)	0.53 (0.43, 0.65)	0.46 (0.38, 0.55)	0.22 (0.18, 0.27)	0.46 (0.35, 0.61)	0.45 (0.36, 0.57)
Interprovincial Migrants vs. All other Manitobans	0.50 (0.42, 0.59)	0.83 (0.59, 0.1.17)	0.92 (0.63, 1.34)	0.30 (0.23, 0.37)	0.85 (0.54,1.34)	0.90 (0.54, 1.52)
Immigrants vs. Interprovincial Migrants	0.54 (0.44, 0.66)	0.63 (0.44, 0.92)	0.50 (0.34, 0.75)	0.75 (0.57, 0.98)	0.54 (0.33, 0.89)	0.50 (0.29, 0.86)
Female						
Immigrants vs. All other Manitobans	0.42 (0.35, 0.49)	0.53 (0.42, 0.67)	0.49 (0.41, 0.59)	0.22 (0.17, 0.29)	0.36 (0.24, 0.53)	0.34 (0.25, 0.47)
Interprovincial Migrants vs. All other Manitobans	0.73 (0.60, 0.90)	0.78 (0.54, 1.13)	0.84 (0.55, 1.28)	0.38 (0.28, 0.51)	0.74 (0.42,1.29)	1.02 (0.55, 1.89)
Immigrants vs. Interprovincial Migrants	0.57 (0.46, 0.71)	0.68 (0.46, 1.00)	0.58 (0.38, 0.90)	0.60 (0.42, 0.85)	0.49 (0.26, 0.91)	0.34 (0.18, 0.65)

Abbreviations: HR: Hazard Ratio; AHR: Adjusted Hazard Ratio; CI: Confidence Intervals
1:1 Matching based on sex, age at the start of follow-up, and place of residence at the start of follow-up

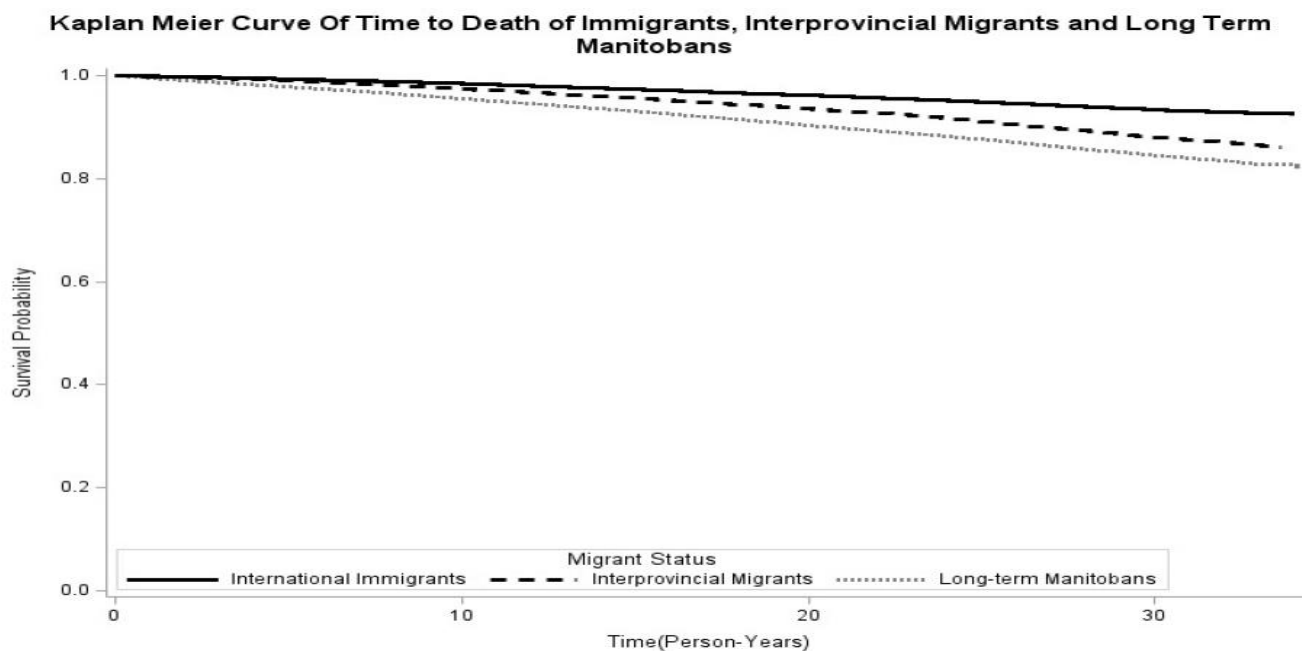
*** Adjusted for relationship status, neighbourhood income quintile, year of the start of healthcare coverage and rural residence

Figure 1.1: Survival curves for all-cause mortality (Panel A) and premature mortality (Panel B) among matched international immigrants, interprovincial migrants and all other Manitobans

Panel A



Panel B



Appendices I .4 and I.5 compare mortality rates between the international and interprovincial migrant groups and all other Manitobans by regional health authority. The tables show lower mortality rates among immigrants compared to interprovincial immigrants and all-other Manitobans in all regional health authorities. The mortality risk gaps between international and interprovincial migrants and all-other Manitobans widened in the Northern Health Region and the Winnipeg Health Authority region.

1.4.3 Mortality according to the characteristics of foreign-born migrants

Table 1.7 shows the rates of all-cause and premature death among all (matched and non-matched) international immigrants. Refugees had a higher mortality risk compared to non-refugees after adjustment. Secondary immigrants had a higher mortality risk initially but not after adjustment, as they were generally older than primary immigrants. Single, never-married individuals had a higher mortality risk than those with a spouse, after adjustment.

There was an inverse relationship between education level and risk of death; immigrants with secondary education or less and those with some post-secondary education faced higher all-cause and premature mortality risks than those with a university degree. Southeast Asians, South Asians, other Asians, and individuals from Latin America and the Caribbean had lower risks of all-cause mortality compared to Western Europeans, but these advantages were not observed for premature mortality. Immigrants from North America and Oceania, groups composed of 86.8% of immigrants from the United States, had a higher risk of both all-cause and premature mortality. A positive association among Eastern Europeans was observed for premature mortality, but no longer statistically significant for all-cause mortality, after adjustment.

Table 1.7: Unadjusted and adjusted incidence rate ratios for all-cause and premature mortality among international immigrants

	All-Cause Mortality		Premature Mortality	
	IRR (95% CI)	AIRR* (95% CI)	IRR (95% CI)	AIRR* (95% CI)
Refugee Status				
Yes	0.78 (0.71, 0.86)	1.27 (1.13, 1.42)	1.35 (1.20, 1.51)	1.38 (1.19, 1.59)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Secondary immigrant				
Yes	1.34 (1.22, 1.46)	1.06 (0.97, 1.17)	1.09 (0.95, 1.25)	0.99 (0.85, 1.15)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Marital status				
Single never married	0.21 (0.19, 0.23)	1.27 (1.13, 1.43)	0.34 (0.30, 0.37)	1.23 (1.07, 1.41)
Married or Common law	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Divorced, separated or widowed	6.73 (6.22, 7.28)	1.08 (0.98, 1.19)	2.30 (1.86, 2.84)	0.96 (0.77, 1.20)
Unknown	2.69 (2.17, 3.33)	1.02 (0.82, 1.27)	2.12 (1.50, 3.02)	1.06 (0.75, 1.52)
Educational attainment				
Secondary or less	2.08 (1.89, 2.29)	1.41 (1.27, 1.58)	1.30 (1.15, 1.47)	1.48 (1.29, 1.70)
Trade/Certificate/Post Sec.	1.50 (1.34, 1.69)	1.28 (1.14, 1.44)	1.51 (1.32, 1.74)	1.35 (1.17, 1.57)
University degree	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
Unknown	1.09 (0.96, 1.24)	1.26 (1.09, 1.47)	0.51 (0.41, 0.62)	1.25 (0.99, 1.58)
Knowledge of English/French				
Yes	0.87 (0.82, 0.93)	1.03 (0.96, 1.12)	0.99 (0.90, 1.09)	0.96 (0.85, 1.07)
No	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
World region of origin				
Southeast Asia	0.94 (0.85, 1.04)	0.88 (0.78, 0.98)	1.11 (0.95, 1.30)	1.14 (0.96, 1.35)
South Asia	0.81 (0.71, 0.93)	0.74 (0.64, 0.85)	1.02 (0.84, 1.24)	1.03 (0.84, 1.28)
Rest of Asia	0.74(0.65, 0.84)	0.67 (0.58, 0.77)	0.93 (0.77, 1.13)	0.86 (0.70, 1.06)
East Europe	1.17 (1.03, 1.33)	1.11 (0.97, 1.27)	1.60 (1.33, 1.94)	1.28 (1.05, 1.56)
Rest of Europe	1.00 (ref)	1.00 (ref)	1.00 (ref)	1.00 (ref)
North Africa	0.50 (0.35, 0.71)	0.94 (0.66, 1.34)	0.88 (0.57, 1.34)	1.16 (0.75, 1.79)
East Africa	0.50 (0.40, 0.63)	0.89 (0.70, 1.13)	1.06 (0.82, 1.38)	1.13 (0.85, 1.50)
Rest of Africa	0.50 (0.39, 0.65)	0.85 (0.65, 1.09)	0.87 (0.64, 1.19)	1.11 (0.80, 1.53)
North America & Oceania	1.82 (1.54, 2.14)	1.27 (1.07, 1.50)	1.64 (1.25, 2.15)	1.57 (1.19, 2.06)
Latin America & Caribbean	0.78 (0.68, 0.90)	0.77 (0.67, 0.89)	0.98 (0.79, 1.21)	0.82 (0.66, 1.01)

Abbreviations: IRR: Incidence rate ratio; AIRR: Adjusted incidence rate ratio; CI: Confidence intervals. Estimates obtained with conditional Poisson regression with person-years as an offset variable

* Adjusted for the start of the follow-up year, age at the start of the follow-up (age, age-squared, and age cube), sex, neighbourhood income quintile, rural residence and all the other variables in the table.

1.4.4 Mortality among Interprovincial migrants

Table 1.8 shows that migrants from all provinces except British Columbia, especially those from Eastern Canada, had a lower risk of death than those from Ontario, the most populous Canadian province.

Table 1.8: Crude and adjusted incidence rate ratios for all-cause and premature mortality among interprovincial migrants

	All-Cause Mortality		Premature Mortality	
	IRR	AIRR*	IRR	AIRR*
Province of Origin				
British Columbia	1.41 (1.34, 1.48)	1.01 (0.96, 1.06)	1.18 (1.08, 1.28)	1.05 (0.97, 1.15)
Alberta	0.75 (0.72, 0.79)	1.03 (0.97, 1.08)	1.03 (0.95, 1.11)	1.05 (0.97, 1.14)
Saskatchewan	0.92 (0.87, 0.97)	1.00 (0.94, 1.05)	0.85 (0.78, 0.93)	0.94 (0.86, 1.02)
Ontario	Ref.	Ref.	Ref.	Ref.
Quebec	0.96 (0.87, 1.06)	0.85 (0.77, 0.94)	0.87 (0.73, 1.02)	0.78 (0.66, 0.93)
Atlantic Canada (NB, NS, PE)	0.50 (0.46, 0.56)	0.82 (0.74, 0.90)	0.65 (0.56, 0.74)	0.77 (0.66, 0.88)
Artic (NT, YK)	0.63 (0.53, 0.76)	0.97 (0.81, 1.16)	1.02 (0.67, 1.05)	0.97 (0.77, 1.22)

Abbreviations: IRR: Incidence rate ratio; AIRR: Adjusted incidence rate ratio; CI: Confidence intervals

Estimates obtained with conditional Poisson regression with person-years as an offset variable
NB: New Brunswick; NS: Nova Scotia; PE: Prince Edward Island; NT: Northwestern Territories; YK: Yukon

* Adjusted for the start of the follow-up year, age at the start of the follow-up (age, age-squared, and age cube), sex, relationship status, neighbourhood income quintile, and rural or urban residence.

1.5 Discussion

1.5.1 Main findings

The study found that both international immigrants and interprovincial migrants had lower mortality risks than the local Manitoban population. However, the migrant mortality advantage was stronger for international migrants than for interprovincial ones. Among these

two migrant groups, there was heterogeneity in mortality risk based on migrants' characteristics; specifically, higher risks were observed among refugees, individuals from North America, and those with lower educational attainment. Internal migrants from eastern Canadian provinces exhibited lower mortality risks.

1.5.2 Limitations

There were some limitations to this study. Socio-demographic information was only collected from the IRCC permanent residence data and the Manitoba health insurance registry. Temporary residents, such as international visa students, work permit holders, and refugee claimants waiting for a decision, were not included in this study. Although immigrants lost to follow-up were censored, it is possible that some of them may have died shortly after remigrating and could not contribute to the numerator, thus underestimating their mortality risk (Andersson & Drefahl, 2017; Wallace & Kulu, 2018); however, this study addressed the salmon bias effect using inverse probability of censoring weight (Howe et al., 2016) in the model and found very minimal impact on estimates.

But this study could not distinguish those who left the province and returned to their country or province of origin due to ill health from those who remigrated to another destination and may be healthier. Some people argue that sick immigrants may choose to remain in the host country because of its superior healthcare and access to medical resources. They might also find it difficult to return to their home country because family members have settled in the host country (Norredam et al., 2015; Razum et al., 1998). Some immigrant characteristics were measured at the time of arrival and could not be updated at a later time, such as education and marital status. The study also lacked measures of morbidity and information on the medical history of migrants before arriving in the country and the province.

Finally, since the study aimed to examine the overall mortality gradient among international, interprovincial migrants and non-migrants, more detailed analyses of specific mechanisms affecting particular subgroups based on place of origin, time of arrival, and other migrant characteristics were beyond its scope.

1.5.3 Interpretation

This study confirmed the lower risk of mortality among immigrants in Canada. It found that both international and interprovincial migrants have a mortality advantage over the local Manitoban population. It also revealed that interprovincial migrants had death rates that were between those of the other two groups. This suggests that, although migrants in general are healthier than non-migrants, international migration is associated with a stronger protective effect than internal migration, which might reflect a stronger selection process for migration. While interprovincial migrants share language, political, and cultural similarities with the local population, their migration choices may be driven by better health status, possibly explaining their mortality advantage (Westphal, 2016).

However, since the migration experience of interprovincial migrants is less dramatic than that of international immigrants, the effect is consequently less noticeable. Results also show that the difference in all-cause and premature mortality rates was greater between the two groups of migrants compared to Manitobans than between the two migrant groups. This suggests that lower life expectancy among Manitobans overall, and Indigenous groups in particular, who are common in Manitoba and are known to have a lower life expectancy than the rest of the population, may influence these results (Katz et al., 2021).

In analyses focusing solely on international immigrants, the study found that refugees faced higher risks of all-cause and premature mortality compared to non-refugees, even after

adjustments. This link may reflect particular health determinants not shared by their non-refugee counterparts, such as involuntary and forced migration, political unrest and persecution, potential exposure to refugee camps, and limited access to quality healthcare and living conditions during migration (Wanigaratne et al., 2016). Additionally, in 2002, the Canadian Immigration and Refugee Protection Act revised immigration selection criteria, exempting certain immigrant groups (e.g., refugees and the family class) from inadmissibility based on health reasons (Government of Canada, 2001), which may have also led to the admission of less healthy refugees. Secondary immigrants showed higher unadjusted mortality rates, primarily because they were older (Appendix I.6 and Appendix I.7) on average than primary immigrants; however, these associations disappeared after adjustment. These results do not support a secondary migration advantage in mortality—seen in reproductive health (Urquia et al., 2010), especially among non-refugees (Wanigaratne et al., 2016).

Finally, there were differences based on immigrants' birthplace. Consistent with previous Canadian studies (Ng, 2011; Ng & LHAD Research Team, 2011), Asian immigrants had low mortality rates, likely due to healthier diets and behaviours. East Europeans showed higher premature mortality in our study, possibly linked to a greater prevalence of risk factors for chronic diseases and death, such as smoking, alcohol use, and poor diet (McKee & Shkolnikov, 2001; Powles et al., 2005). The reasons behind the excess mortality among those from North America and Oceania are less clear; this group mainly includes immigrants from the United States. Future studies should examine whether migration from the United States to Manitoba is associated with negative health selection, while also considering the potential impact of various First Nations or American Indian Nations, which hold cross-border rights due to their original

territories and have had their family and social lives disrupted by the US-Canada border (Assembly of First Nations, 2020).

In analyses focused on interprovincial migrants, the study found that migrants from British Columbia had a higher unadjusted mortality risk than those from Ontario. However, this excess risk was accounted for by observed individual characteristics. A more consistent finding is the lower mortality among individuals from Eastern Canada (Atlantic Canada and Quebec). Although we lacked additional data, such as socioeconomic status before migration, occupation, or reasons for migrating that could help explain these patterns, the selection hypothesis might suggest that migration from wealthier regions like British Columbia, which has a strong economy and the highest life expectancy among all Canadian provinces (Zhang & Rasali, 2015), may be negatively selected for health. Conversely, migration from provinces with economies that are weaker or similar to Manitoba's, such as those in Eastern Canada (Statistics Canada, 2021), may be positively selected for health.

1.5.4 Policy Implication

Considering the survival advantage of both international immigrants and interprovincial migrants compared to Manitoba residents, efforts to improve life expectancy in Manitoba might be better directed at the local population and high-risk migrant groups, such as refugees.

1.6 Conclusion

This study identified a mortality gradient based on migration status: lower among international immigrants, intermediate among interprovincial migrants, and highest among other long-term Manitoba residents. This gradient likely reflects varying levels of selection for migration; the stronger the selection, the lower the mortality. The findings suggest that efforts to improve life expectancy in Manitoba may be more effective if they focus on the local population.

Despite an overall mortality advantage, there is heterogeneity in mortality risk among immigrants. Understanding the protective factors behind the migrant mortality advantage could help develop prevention strategies for the local population and higher-risk migrant groups, such as refugees and individuals from the United States.

1.7 References

Abraído-Lanza, A. F., Chao, M. T., & Flórez, K. R. (2005). Do healthy behaviors decline with greater acculturation? Implications for the Latino mortality paradox. *Social Science & Medicine* (1982), 61(6): 1243–1255.

Abraído-Lanza, A.F., Dohrenwend, B.P., Ng-Mak, D.S., & Turner, J.B. (1999). The Latino mortality paradox: A test of the “salmon bias” and healthy migrant hypotheses. *American Journal of Public Health*, 89(10): 1543–1548.

Ali, J. S., McDermott, S., & Gravel, R. G. (2004). Recent Research on Immigrant Health from Statistics Canada’s Population Surveys. *Canadian Journal of Public Health*, 95(3), I9–I13.

Andersson, G., & Drefahl, S. (2017). Long-Distance Migration and Mortality in Sweden: Testing the Salmon Bias and Healthy Migrant Hypotheses. *Population, Space and Place*, 23(4).

Anson, J. (2004). The migrant mortality advantage: A 70-month follow-up of the Brussels population. *European Journal of Population*, 20(3): 191–218.

Antecol H, Bedard K (2006) Unhealthy assimilation: do immigrants converge to American weights? *Demography* 43(2):337–360.

Assembly of First Nations. (2020). Registration and the Canada-United States Border. Available at: <https://www.afn.ca/wp-content/uploads/2020/01/07-19-02-06-AFN-Fact-Sheet-Registration-and-the-Canada-US-Border-final-revised.pdf>

Barakat A, Mittal A, Ricketts D, & Rogers BA. (2019). Understanding survival analysis: actuarial life tables and the Kaplan-Meier plot. *Br J Hosp Med (Lond)*,80: 642–6.

Baser O. (2007) Choosing propensity score matching over regression adjustment for causal inference: When, why and how it makes sense. *Journal of Medical Economics*. 10:379–391.

Beiser, M. 2005. The Health of Immigrants and Refugees in Canada. *Canadian Journal of Public Health*, 96(2), S30–S44.

Bordea, E. (2019). Essays on the effect of immigration and assimilation on immigrants’ health and health behaviours: evidence from the United Kingdom and Russian Federation. (Unpublished Doctoral thesis, City, University of London).

- Borjas, G. J., Poutvaara, P., & Kauppinen, I. (2019). Self-selection of emigrants: Theory and evidence on stochastic dominance in observable and unobservable characteristics. *The Economic Journal*, 129(617): 143–171.
- Caselli, F., & National Bureau of Economic Research. (2004). *Accounting for Cross-Country Income Differences*. National Bureau of Economic Research.
- Callas, P. W., Pastides, H., & Hosmer, D. W. (1998). Empirical comparisons of proportional hazards, poisson, and logistic regression modelling of occupational cohort data. *American Journal of Industrial Medicine*, 33(1): 33–47.
- Chiswick, B. (2000). Are Immigrants Favorably Self-Selected? An Economic Analysis. *The Institute for the Study of Labor (IZA)*. Paper no 131.
- Chiu, C.T., Cantu, P.A., Hayward, M.D., & Hummer, R.A. (2012). New estimates of racial/ethnic differences in life expectancy with chronic morbidity and functional loss: Evidence from the National Health Interview Survey. *Journal of Cross-Cultural Gerontology*, 28: 283-297.
- Choy, B., Arunachalam, K., S, G., Taylor, M., & Lee, A. (2021). Systematic review: Acculturation strategies and their impact on the mental health of migrant populations. *Public Health in Practice*, 2, p.100069-100069, Article 100069
- Constant, A. F., Garcia-Munoz, T., Neuman, S., & Neuman, T. (2017). A “healthy immigrant effect” or a “sick immigrant effect”? Selection and policies matter. *The European Journal of Health Economics*, 19(1), 103–121.
- Constant, Amelie F. & García-Muñoz, Teresa & Neuman, Shoshana & Neuman, Tzahi. (2014). "Micro and Macro Determinants of Health: Older Immigrants in Europe," IZA Discussion Papers 8754, Institute of Labor Economics (IZA).
- DesMeules, M., Gold, J., McDermott, S., Cao, Z., Payne, J., Lafrance, B., et al. (2005). Disparities in mortality patterns among Canadian immigrants and refugees, 1980-1998: Results of a national cohort study. *Journal of Immigrant Health*, 7(4): 221–232.
- Dobson, A. J., & Barnett, A. G. (2018). An introduction to generalized linear models (Fourth edition.). CRC Press, Taylor & Francis Group.
- Etikan I, Abubakar S, & Alkassim R. (2017). The Kaplan-Meier estimate in survival analysis. *Biom Biostat Int J*,5:55–9.
- Farre, L. (2016). New evidence on the healthy immigrant effect. *Journal of Population Economics*, 29(2): 365–394.
- Feliciano, C. (2005). “Educational Selectivity in U.S. Immigration: How Do Immigrants Compare to Those Left Behind?” *Demography*, 42(1): 131–52.
- Gadd, M., Johansson, S. E., Sundquist, J., & Wändell, P. (2006). Are there differences in all-cause and coronary heart disease mortality between immigrants in Sweden and in their country of birth? A follow-up study of total populations. *BMC Public Health*, 6, 1–9.

Garibaldi, P. (2006). *Personnel economics in imperfect labor markets* (1st ed.). Oxford, England: Oxford University Press.

George, B., Seals, S., & Aban, I. (2014). Survival analysis and regression models. *Journal of Nuclear Cardiology*, 21(4): 686–694.

Goel MK, Khanna P, & Kishore J. (2010). Understanding survival analysis: Kaplan-Meier estimate. *Int J Ayurveda Res*, 1:274–8.

Government of Canada. (2001). Immigration and Refugee Protection Act (s.c.2001, c.27). Minister of Justice. Justice Laws Website. Available at: <https://www.laws-lois.justice.gc.ca/eng/acts/I-2.5/page-6.html#docCont>. Accessed 22 May 2018.

Grove, N., & A. Zwi. (2006). “Our health and theirs: Forced migration, othering, and public health.” *Social Science and Medicine* 62(8):1931–1942.

Gujarati, D. N. (2003). *Basic econometrics* (4th ed.). McGraw Hill.

Handler, Heinz J., *Economic Links between Education and Migration: An Overview*. (2018). Flash Paper Series, Policy Crossover Center Vienna - Europe, NO. 4/2018

Hollander, A.C., Bruce, D., Ekberg, J., Burström, B., Borrell, C., & Ekblad, S. (2012). Longitudinal study of mortality among refugees in Sweden. *International Journal of Epidemiology*, 41(4), 1153–1161.

Hosmer, D. W., Lemeshow, S., & May, S. (2008). Interpretation of a Fitted Proportional Hazards Regression Model. In *Applied Survival Analysis: Regression Modeling of Time-to-Event Data* (pp. 92–131).

Hossin, M. Z. (2020). International migration and health: it is time to go beyond conventional theoretical frameworks. *BMJ Global Health*, 5(2), Article e001938.

Howe, C. J., Cole, S. R., Lau, B., Napravnik, S., & Joseph J., E. (2016). Selection Bias Due to Loss to Follow Up in Cohort Studies. *Epidemiology*, 27(1), 91–97.

Immigration, Refugees and Citizenship Canada. (n.d). *Health Care Coverage* (2026).<https://www.canada.ca/en/immigration-refugeescitizenship/services/asylum/border/health-coverage.html>

Immigration, Refugees and Citizenship Canada. (n.d). Medical examination for permanent residence applicants .(2025).<https://www.canada.ca/en/immigration-refugees-citizenship/services/application/medical-police/medical-exams/requirements-permanent-residents.html>

Jasso, G., D. Massey, M. Rosenzweig, & J. Smith (2004). 'Immigrant Health: Selectivity and Acculturation', Chapter 7 in Anderson, Bulatao and Cohen (eds) *Critical Perspectives on Racial and Ethnic Differences in Health in Late Life*, Committee on Population, National Research Council, Washington, DC: The National Academies Press.

Juárez, S., Honkaniemi, H., Dunlavy, A., Aldridge, R., Barreto, M., Katikireddi, S., & Rostila, M. (2019). Effects of non-health-targeted policies on migrant health: a systematic review and meta-analysis. *The Lancet Global Health*, 7(4): e420–e435.

Justice Laws Website. (2001). Part 1 Immigration to Canada DIVISION 4 Inadmissibility Sections 36-38 in Immigration and Refugee Protection Act (s.c.2001, c.27). Accessed May 22, 2018.

Katz, A., Kinew, K. A., Star, L., Taylor, C., Koseva, I., Lavoie, J., et al. (2019). *The Health Status of and Access to Healthcare by Registered First Nation Peoples in Manitoba*. Winnipeg, MB. Manitoba Centre for Health Policy.

Katz, A., Urquia, M. L., Star, L., Lavoie, J. G., Taylor, C., Château, D., Enns, J. E., Tait, M. J., & Burchill, C. (2021). Changes in health indicator gaps between First Nations and other residents of Manitoba. *Canadian Medical Association Journal*, 193(48): E1830–E1835.

Kennedy, S., J. T. McDonald, and N. Biddle. (2006). *The Healthy Immigrant Effect and Immigrant Selection: Evidence from Four Countries*. SEDAP Research Paper No. 164.

Khan, A., Urquia, M., Kornas, K., Henry, D., Cheng, S., & Bornbaum, et al. (2017). Socioeconomic gradients in all-cause, premature and avoidable mortality among immigrants and long-term residents using linked death records in Ontario, Canada. *Journal of Epidemiology and Community Health*. 71(7): 625-632.

Khlat, M., & Darmon, N. (2003). Is there a Mediterranean migrants mortality paradox in Europe? *International Journal of Epidemiology*, 32(6): 1115–1118.

Lu, C., & Ng, E. (2019). Healthy immigrant effect by immigrant category in Canada. *Health Reports*, 30(4), 3–11.

Lenhart, O. (2019). The effects of income on health: new evidence from the Earned Income Tax Credit. *Review of Economics of the Household*, 17(2), 377–410.

McKay, L., Macintyre, S., & Ellaway, A. (2003). *Migration and health: a review of the international literature*. Medical Research Council Occasional Paper No 12.

McKee, M., & Shkolnikov, V. (2001). Understanding the toll of premature death among men in Eastern Europe. *British Medical Journal*, 323: 1051–1055.

Moullan, Y., & Jusot, F. (2014). Why is the “healthy immigrant effect” different between European countries? *European Journal of Public Health*, 24(SUPPL.1): 80–86.

Namer, Y., and Razum, O. (2018). Convergence Theory and the Salmon Effect in Migrant Health. 10.1093.

Neuman, S. Are immigrants healthier than native residents?. IZA World of Labor 2014: 108
Newbold, K.B. (2006). Chronic conditions and the healthy immigrant effect: Evidence from Canadian immigrants. *Journal of Ethnic and Migration Studies*, 32(5): 765–784.

Ng, E. (2011). The healthy immigrant effect and mortality rates. *Health Reports*, 22(4):25-9

- Ng, E., & LHAD Research Team. (2011). Insights into the healthy immigrant effect: Mortality by period of immigration and birthplace. *Health Reports*, 8: 1–16.
- Ng, E., Wilkins, R., Gendron, F., & Berthelot, J. (2005). Dynamics of immigrants' health: Evidence from Canada, 1994-95 to 2002-03. Summary Report. *Canadian Studies in Population*, 32(1), 131–.
- Nielsen, S.S., & Krasnik, A. (2010). Poorer self-perceived health among migrants and ethnic minorities versus the majority population in Europe: A systematic review. *International Journal of Public Health*, 55(5): 357–371.
- Norredam, M., Hansen, O. H., Petersen, J. H., Kunst, A. E., Kristiansen, M., Krasnik, A., & Agyemang, C. (2015). Remigration of migrants with severe disease: myth or reality? a register-based cohort study. *European Journal of Public Health*, 25(1): 84–89.
- Norredam, M., Olsbjerg, M., Petersen, J.H., Juel, K., & Krasnik, A. (2012). Inequalities in mortality among refugees and immigrants compared to native Danes - A historical prospective cohort study. *BMC Public Health*, Vol. 12 (1), p.757-757, Article 757
- Omariba, D.W.R., Ng, E., & Vissandjée, B. (2014). Differences between immigrants at various durations of residence and host population in all-cause mortality, Canada 1991-2006. *Population Studies*, 68(3), 339–357.
- Orrenius, P. M., and M. Zavodny. (2009). “Do immigrants work in riskier jobs?” *Demography* 46:3:535–551.
- Palloni, A., & Arias, E. (2004). Paradox lost explaining the Hispanic adult mortality advantage. *Demography*, 41(3), 385–415.
- Pedersen, J., M. Pytlikova, & Smith, N. (2006), "Migration into OECD countries 1990-2000", in: C. Parsons, T. Smeeding (eds), *Immigration and the transformation of Europe*, Cambridge University Press. Cambridge.
- Picot, G., Hou, F., & Qiu, T. (2014). *The human capital model of selection and the long-run economic outcomes of immigrants*. Statistics Canada.
- Portes, A., & Zhou, M. (1993). The New Second Generation: Segmented Assimilation and Its Variants. *The Annals of the American Academy of Political and Social Science*, 530(1): 74–96.
- Powles, J. (1990) ‘The best of both worlds: attempting to explain the persisting low mortality of Greek migrants to Australia’. In J. Caldwell, S. Findlay, P Caldwell and G. Santow (eds.) *What we know about health transition: the cultural, social and behavioural determinants of Health*, Canberra: Health Transition Center.
- Powles, J.W., Zatonski, W., Vander Hoorn, S., & Ezzati, M. (2005). The contribution of leading diseases and risk factors to excess losses of healthy life in Eastern Europe: Burden of disease study. *BMC Public Health*, Vol. 5 (1), p.116-116, Article 116

Raghupathi, V., & Raghupathi, W. (2020). The influence of education on health: an empirical assessment of OECD countries for the period 1995–2015. *Archives of Public Health = Archives Belges de Santé Publique*, 78(1), Article 20.

Razum, O. (2008). Migrant Mortality, Healthy Migrant Effect. In W. Kirch (Ed.), *Encyclopedia of Public Health* (pp. 932–935). Springer: Netherlands.

Razum, O., & Twardella, D. (2002). Viewpoint: Time travel with oliver twist - Towards an explanation for a paradoxically low mortality among recent immigrants. *Tropical Medicine & International Health*, 7(1): 4–10.

Razum, O., Zeeb, H., Akgün, H. S., & Yilmaz, S. (1998). Low overall mortality of Turkish residents in Germany persists and extends into a second generation: merely a healthy migrant effect? *Tropical Medicine & International Health*, 3(4): 297–303.

Riosmena, F., Kuhn, R., & Jochem, W. C. (2017). Explaining the Immigrant Health Advantage: Self-selection and Protection in Health-Related Factors Among Five Major National-Origin Immigrant Groups in the United States. *Demography*, 54(1): 175–200.

Riosmena, F., Wong, R., & Palloni, A. (2013). Migration Selection, Protection, and Acculturation in Health: A Binational Perspective on Older Adults. *Demography*, 50(3): 1039–1064.

Ronellenfitch, U., & Razum, O. (2004). Deteriorating health satisfaction among immigrants from Eastern Europe to Germany. *International Journal for Equity in Health*, 3(1), Article 4:1–10.

Rosenwaike, I., & Hempstead, K. (1990). Mortality among three Puerto Rican populations: residents of Puerto Rico and migrants in New York City and in the balance of the United States, 1979–81. *International Migration Review*, 24(4): 684–702.

Rubin, D.B. (2001). Using Propensity Scores to Help Design Observational Studies: Application to the Tobacco Litigation. *Health Services & Outcomes Research Methodology*, 2: 169–188.

Schober, P., & Vetter, T. R. (2018). Survival Analysis and Interpretation of Time-to-Event Data: The Tortoise and the Hare. *Anesthesia and Analgesia*, 127(3): 792–798.

Sharma, R.D., Michalowski, M., & Verma, R.B. (1990). Mortality differentials among immigrant populations in Canada. *International Migration*, 28(4): 443–450.

Solé-Auró, A., & Crimmins, E.M. (2008). Health of immigrants in European countries. *International Migration Review*, 42(4): 861–876.

Statistics Canada. (2021). “Gross domestic product, expenditure-based, provincial and territorial, annual”. Available at: <https://www150.statcan.gc.ca/t1/tbl1/en/cv.action?pid=3610022201> Last accessed: May 27, 2021.

Sundquist, K., & Li, X. (2006). Coronary heart disease risks in first- and second-generation immigrants in Sweden: A follow-up study. *Journal of Internal Medicine*, 259(4): 418–427.

Uitenbroek, D. G. (2015). Mortality trends among migrant groups living in Amsterdam. *BMC Public Health*, 15(1), 1187–1187.

- Urquia, M., Walld, R., Wanigaratne, S., Eze, N., Azimae, M., McDonald, J.T. and Guttmann, A. (2021). "Linking National Immigration Data to Provincial Repositories: The case of Canada", *International Journal of Population Data Science*, 6:1-19.
- Urquia, M.L., Frank, J.W., & Glazier, R.H. (2010). From places to flows. International secondary migration and birth outcomes. *Social Science and Medicine*, 71(9): 1620–1626.
- Valles, S. A. (2016). The challenges of choosing and explaining a phenomenon in epidemiological research on the "Hispanic Paradox." *Theoretical Medicine and Bioethics*, 37(2), 129–148.
- Viruell-Fuentes, E. A. (2007). Beyond acculturation: immigration, discrimination, and health research among Mexicans in the United States. *Social Science & Medicine*, 65(7), 1524-1535.
- Wallace, M., & Kulu, H. (2014). Migration and Health in England and Scotland: a Study of Migrant Selectivity and Salmon Bias: Migration and Health in England and Scotland. *Population Space and Place*, 20(8): 694–708.
- Wallace, M., & Kulu, H. (2018). Can the salmon bias effect explain the migrant mortality advantage in England and Wales? *Population, Space and Place*, 24:e2146
- Wanigaratne, S., Cole, D., Bassil, K., Hyman, I., Moineddin, R., & Urquia, M. (2015). Contribution of HIV to Maternal Morbidity Among Refugee Women in Canada. *American Journal of Public Health*, 105(12): 2449–2456.
- Wanigaratne, S., Cole, D.C., Bassil, K., Hyman, I., Moineddin, R., & Urquia, M.L. (2016). The influence of refugee status and secondary migration on preterm birth. *Journal of Epidemiology and Community Health*, 70(6): 622–628.
- Westphal, C. (2016). Healthy Migrants? Health Selection of Internal Migrants in Germany. *European Journal of Population*, 32(5): 703–730.
- Wingate, M.S., Alexander, G.R. (2006). The healthy migrant theory: variations in pregnancy outcomes among US-born migrants. *Soc Sci Med. Jan*;62(2):491-8.
- Yang, W., Jepson, C., Xie, D., Roy, J. A., Shou, H., Hsu, J. Y., Anderson, A. H., Landis, J. R., He, J., Feldman, H. I., & Chronic Renal Insufficiency Cohort (CRIC) Study Investigators (2017). Statistical Methods for Recurrent Event Analysis in Cohort Studies of CKD. *Clinical journal of the American Society of Nephrology*, 12(12): 2066–2073.
- Zhang, L.R., & Rasali, D. (2015). Life expectancy ranking of Canadians among the populations in selected OECD countries and its disparities among British Columbians. *Archives of Public Health*, 73(1): 1–10.

Appendix I

Appendix I.1 Data Linkage

All different databases are connected to the Manitoba registry, which is a vital part of the repository. Operating since 1970, the registry provides records for the unique Personal Health Identification Number (PHIN) for everyone registered with the Department of Manitoba Health, Seniors and Active Living (MHSAL). It is a long-term, population-based database containing essential demographic details about individuals, household addresses, and residential postal codes. The registry collects semi-annual data from Manitoba Health on birth dates, entry dates into the province, and other immigration-related information. The link between the permanent residence database from 1985 to 2017 and the registry added a new layer of information on immigrants. This database contains details about the immigration category, family composition, landing date, intended destination, knowledge of official languages, and socio-demographic characteristics of the applicants (e.g., marital status, education, occupation, country of birth, last permanent residence, mother tongue, age, and sex). It was linked to the registry based on previous data linkage work conducted in Ontario (Urquia, M. et al., 2021). Blocking schemes were used for records via deterministic, probabilistic, and manual matching techniques.

Deterministic matching

Information about the individuals enrolled in the permanent residence database exactly matched the registry contents using a combination of personal identifiers, such as name (first name, middle name, and surname), gender, and/or date of birth.

Probabilistic matching

The records from two different files of individuals were matched using linkage keys: first name, initial of the first name, first three characters of the first name, tokenized first name, middle name, surname, first initial of the surname, first three characters of the surname, the town of intended destination in Manitoba, birth year/month/day, and sex.

Manual matching

The MCHP (Manitoba Centre for Health Policy) data analysts have manually matched individuals' information using personal identifiers such as their first, middle, and last names, gender, date of birth, and other relevant personal characteristics. Over 90% (236,657) of observations were matched through deterministic matching. Probabilistic and manual matching yielded 10,542 and 3685 matches, respectively.

Appendix I.2 Balance Assessment of Matching Variables Between Immigrants and All-Other Manitobans in the Matched Cohort

Variable	Standardized Mean Differences (SMD) between Immigrants and All-other Manitobans
Year of birth	0.003
Sex	0.000
Place of Residence	0.009

Appendix I.3 Balance Assessment of Matching Variables Between Immigrants and interprovincial migrants in the Matched Cohort

Variable	Standardized Mean Differences (SMD) between Immigrants and All-other Manitobans
Year of birth	0.094
Sex	0.003
Place of Residence	0.067

Appendix I.4 Person-years and crude mortality rates (per 1000 person-years) for all-cause mortality among international Migrants (N=118,398), Interprovincial Migrants (N=118,398), and all other Manitobans (N=118,398) by Regional Health Authority

	International Immigrants		Interprovincial Migrants		All other Manitobans	
	Person-years (No of Deaths)	Rate	Person-years (No of Deaths)	Rate	Person-years (No of Deaths)	Rate
Regional Health Authority						
Interlake-Eastern Regional Health Authority	32,098 (81)	2.52	26,104 (118)	4.52	43,078 (177)	4.10
Northern Health Region	20,747 (32)	1.54	20,730 (50)	2.41	34,824 (179)	5.14
Prairie Mountain Health	99,059 (168)	1.69	87,000 (354)	4.06	128,672 (431)	3.34
Southern Health-Sante Sud	121,886 (164)	1.34	82,136 (288)	3.50	148,871 (324)	2.17
Winnipeg Regional Health Authority	1,111,873 (2739)	2.46	699,326 (3201)	4.57	1,299,424 (8104)	6.23

Appendix I.5 Unadjusted and adjusted incidence rate ratios for all-cause and premature mortality among comparison groups by Regional Health Authority

Regional Health Authority	All-Cause Mortality		Premature Mortality	
	IRR (95% CI)	AIRR ^a (95% CI)	IRR (95% CI)	AIRR ^a (95% CI)
Interlake-Eastern Regional Health Authority				
IM vs. AOM	0.57 (0.44, 0.73)	0.59 (0.47, 0.75)	0.45 (0.30, 0.67)	0.46 (0.31, 0.68)
IPM vs. AOM	1.09 (0.85, 1.40)	0.78 (0.63, 0.96)	0.98 (0.70, 1.37)	0.77 (0.55, 1.07)
IM vs. IPM	0.52 (0.38, 0.71)	0.76 (0.59, 0.99)	0.46 (0.29, 0.71)	0.59 (0.38, 0.90)
Northern Health Region				
IM vs. AOM	0.28 (0.0.18, 0.41)	0.27 (0.19, 0.39)	0.24 (0.15, 0.39)	0.26 (0.16, 0.42)
IPM vs. AOM	0.46 (0.34, 0.64)	0.53 (0.39, 0.72)	0.40 (0.27, 0.60)	0.43 (0.29, 0.63)
IM vs. IPM	0.59 (0.36, 0.96)	0.51 (0.33, 0.78)	0.60 (0.34, 1.06)	0.59 (0.33, 1.05)
Prairie Mountain Health				
IM vs. AOM	0.33 (0.29, 0.38)	0.52 (0.44, 0.61)	0.39 (0.30, 0.51)	0.42 (0.33, 0.55)
IPM vs. AOM	1.62 (1.47, 1.77)	0.75 (0.66, 0.86)	0.96 (0.78, 1.18)	0.78 (0.63, 0.95)
IM vs. IPM	0.21 (0.18, 0.24)	0.69 (0.58, 0.81)	0.41 (0.31, 0.54)	0.56 (0.42, 0.74)
Southern Health-Sante Sud				
IM vs. AOM	0.59 (0.49, 0.71)	0.65 (0.55, 0.78)	0.55 (0.44, 0.71)	0.59 (0.46, 0.75)
IPM vs. AOM	1.65 (1.40, 1.94)	0.87 (0.74, 1.03)	1.14 (0.91, 1.42)	0.90 (0.72, 1.13)
IM vs. IPM	0.36 (0.29, 0.44)	0.75 (0.62, 0.90)	0.49 (0.37, 0.64)	0.66 (0.50, 0.87)
Winnipeg Regional Health Authority				
IM vs. AOM	0.38 (0.36, 0.39)	0.42 (0.40, 0.44)	0.28 (0.26, 0.30)	0.32 (0.30, 0.34)
IPM vs. AOM	0.72 (0.69, 0.75)	0.74 (0.71, 0.77)	0.59 (0.56, 0.62)	0.61 (0.58, 0.64)
IM vs. IPM	0.52 (0.50, 0.55)	0.57 (0.54, 0.60)	0.47 (0.44, 0.51)	0.52 (0.48, 0.56)

Abbreviations: IRR: Incidence Rate Ratio; AIRR: Adjusted Incidence Rate Ratio; CI: Confidence Interval. IM: International migrants, IPM: Interprovincial migrants, AOM: All other Manitoban 1:1 matching based on sex, age at start of follow-up and place of residence at start of follow-up. Estimates obtained with Conditional Poisson regression with person-years as an offset variable.
^a Adjusted for relationship status, neighbourhood income quintile and rural residence

Appendix I.6 Age distribution of Immigrants by immigrant type (primary or secondary)

Age group	Primary Immigrant N (%)	Secondary Immigrant N (%)	Total N (%)
0-14	46445 (22.39)	5547 (2.67)	51992 (25.07)
15-24	29266 (14.11)	4345 (2.09)	33611 (16.20)
25-44	81407 (39.25)	14041 (6.77)	95448 (46.02)
45-64	18413 (8.88)	3572 (1.72)	21985 (10.60)
65-84	3480 (1.68)	783 (0.38)	4263 (2.06)
85 and above	85 (0.04)	30 (0.01)	115 (0.06)
Total	179096 (86.35)	28318 (13.65)	207414 (100.00)

Appendix I.7 Age distribution of Immigrants by immigrant type (primary or secondary) (PMR cohort, Age < 71)

Age group	Primary Immigrant N (%)	Secondary Immigrant N (%)	Total N (%)
0-14	46445 (22.39)	5547 (2.67)	51992 (25.07)
15-24	29266 (14.11)	4345 (2.09)	33611 (16.20)
25-44	81407 (39.25)	14041 (6.77)	95448 (46.02)
45-64	18413 (8.88)	3572 (1.72)	21985 (10.60)
65-70	1983 (0.96)	395 (0.19)	2378 (1.15)
Total	177514 (86.42)	27900 (13.58)	205414 (100.00)

CHAPTER 2

HEALTHCARE COSTS AT THE END-OF-LIFE AMONG IMMIGRANTS AND NON-IMMIGRANTS, MANITOBA, CANADA

ABSTRACT

Objectives: Recognizing the higher end-of-life (EOL) healthcare costs, this study compares healthcare costs of immigrants and non-immigrants and identifies factors associated with healthcare costs during the last year of life.

Methods: A retrospective matched-cohort study was conducted to compare end-of-life healthcare costs for immigrants and non-immigrants who died in Manitoba between January 2005 and March 2022. The linked administrative dataset was used to extract healthcare costs from various sources, such as hospitals, physician services, drug prescriptions, home care, and long-term care, as well as to determine immigration status and sociodemographic details. The zero-inflated gamma hurdle model (ZIG) and quantile regression were employed to analyze costs expressed in 2022 Canadian dollars (\$CA).

Results: In the last year of life, average healthcare costs were CA\$43961 for immigrants (N=2469) and CA\$22156 for non-immigrants (N=4741). A higher percentage of immigrants (74.5%) used inpatient hospital care compared to non-immigrants (34%). Overall, immigrants had significantly higher EOL costs (adjusted mean difference (aMD): \$16939; 95% confidence interval (CI: \$14473, \$19404) than non-immigrants. Cost disparities were higher among those with five or more comorbidities (aMD: \$38874; 95% CI: \$34128, \$43619), hospital deaths (aMD: \$38319; 95% CI: \$34391, \$42246), inpatient hospital care (aMD: \$10923; 95% CI: \$6951, \$14894) and long-term care (LTC) (aMD: -\$20120; 95% CI: -\$23025, -\$19695).

Quantile regression showed that the differences were more pronounced among high-cost patients (top 1%, aMD: \$96086; 95% CI: \$68456, \$123716).

Conclusion: Immigrants incurred higher EOL healthcare costs (HC) than non-immigrants in Manitoba, driven by their higher hospitalization.

2.1 Introduction

The healthcare needs of individuals typically rise during their end-of-life (EOL) (Lubitz, 1993; Menec V, 2004; Tanuseputro et al., 2015). The high expenses associated with EOL care significantly contribute to escalating annual healthcare costs (Menec V, 2004; Tanuseputro et al., 2015). The EOL HC (health care costs) captures approximately 10% of the annual government-funded healthcare budget for less than 2% of the total population in Ontario (Tanuseputro et al., 2015). In the United States, between 13% and 25% of Medicare program expenses, depending on cost-estimation methods and assumptions, is attributable to healthcare in patients' last year of life (Duncan et al., 2019). The growing number of Canadians and Americans aged over 65 and aging baby boomers puts pressure on the healthcare system and highlights the importance of EOL care (Canadian Institute for Health Information, 2017; Fowler, 2013; Needham et al., 2005; Song & Ferris, 2018).

Generally, immigrants are healthier and incur lower healthcare costs upon arrival compared to non-immigrants. This is known as the healthy immigrant effect (Ciupitu-Plath, 2014; Goettler, 2020), and it is more noticeable among recent immigrants from non-European backgrounds (Vang et al., 2017). However, the health advantage may be less evident among immigrants arriving at an older age (Markides, 2011), especially if they are sponsored to Canada by family due to declining health and/or widowhood (Markides, 2011). The initial health benefits of immigrants might decline over time as they adapt to new lifestyles, including changes in eating habits, smoking, and alcohol consumption (Constant Amelie F. et al., 2017). Challenges such as difficulty accessing healthcare, job insecurity, working conditions, and discrimination might negatively impact immigrant health (Ciupitu-Plath, 2014; Goettler, 2020; Hall & Cuellar, 2016). Additionally, socioeconomic disadvantages faced in childhood and the healthcare system

in their country of origin may delay or prevent early healthcare service use (Fortuna et al., 2008; Jatrana et al., 2014; Marmot & Bell, 2012; Pati et al., 2023). This delay can lead to more advanced disease progression, more complications, and influence end-of-life healthcare later in life (Fortuna et al., 2008; Marmot & Bell, 2012; Pati et al., 2023; Sangalang et al., 2019).

Studies in North America indicate that immigrants may receive more aggressive treatments and ICU admissions than non-immigrants. For example, a study in Ontario found that 25% of immigrants were admitted to ICUs, compared with 19% of non-immigrants (Quach et al., 2021). Furthermore, immigrants are more likely to die in acute healthcare settings (Quach et al., 2021). Research on end-of-life (EOL) overall healthcare costs comparing immigrants and non-immigrants within a universal healthcare system is limited. While some studies have examined overall EOL healthcare for the entire population (Menec et al., 2004; Tanuseputro et al., 2015; Canadian Institute for Health Information (CIHI, 2025), there is a lack of comparisons of aggregate EOL care costs specifically between immigrants and non-immigrants, as well as among different immigrant sub-groups and sex differences. Moreover, existing comparisons mainly focus on EOL acute healthcare use and the locations of death (Van Spall et al., 2021; Less CS et al., 2024; Yarnell et al., 2020), but do not analyze differences across the entire cost distribution. Gaining a better understanding of healthcare service use patterns and costs for immigrants and non-immigrants at the EOL could help improve healthcare services and reduce unnecessary system costs.

Using multiple healthcare sources, this population-based data linkage study aimed to compare EOL HC overall, and by healthcare sources, between immigrants and non-immigrant residents of Manitoba, a Canadian province with universal and free healthcare for residents. It

also examined cost differences according to sex and immigration characteristics, such as years since immigration.

2.2 Methods

2.2.1 Data sources

The Immigration, Refugees and Citizenship Canada (IRCC) permanent resident database was used to determine immigrant status. The Manitoba Health Insurance Registry identified eligible individuals to form the cohort and provided sociodemographic details. Relevant healthcare datasets, including those for medical services, medication, hospital stays, emergency department (ED) visits, home care, and long-term care (LTC), were used to estimate healthcare utilization. The Vital Statistics Mortality database assessed causes of death. Additional datasets measured covariates such as rent assistance (Rent Aid database), welfare (Employment and Income Assistance database), and neighbourhood income quintiles (Canadian Censuses). All datasets were linked via scrambled Personal Health Identification Numbers of decedents.

2.2.2 Study Population

The study included immigrants and non-immigrants aged 50 or older at the time of death who died between January 1, 2005, and March 31, 2022, with valid registrations in the Manitoba Health Insurance Registry (the Registry). I excluded temporary residents and decedents without at least one year of healthcare coverage prior to their death.

2.2.3 Variable definitions

2.2.3.1 Outcome variable

The total direct costs included all expenses from various sources incurred during the end-of-life (EOL) of the deceased individuals. Costs were adjusted to 2022 Canadian dollars using

Manitoba's Consumer Price Index (CPI) for health and personal care. Costs for inpatient hospitalization and day surgery were calculated based on the Resource Intensity Weight (RIW) from the Canadian Institute for Health Information (Johnson, 1998; CIHI,2022). The net physician service fees and diagnostic test costs were obtained from the medical service dataset, which covers ambulatory services, lab and pathology claims, minor surgeries, out-of-province services, and certain in-hospital services funded by the Manitoba government.

The government-funded drug costs were calculated using the Drug Program Information Network (DPIN) dataset for total prescription expenses and professional (dispensing) fees. Long-term care (LTC) costs were determined through assessment and utilization files to identify the total number of resident days and the per diem rates paid by the Manitoba government. The per diem cost of home care for each year was computed based on Manitoba Health's annual expenditures for the home care program and the total days individuals received home care during their final year of life, collected from home care assessments, utilization records, and the home care Procura datasets. Furthermore, emergency department costs were estimated using the average direct cost per visit from CIHI data and the number of visits per individual, obtained from Emergency Department Information System (EDIS), Emergency – Admission, Discharge and Transfer (ADT), and E-Triage.

Definitions and data sources, including relevant 10th Revision of the International Classification of Diseases (ICD-10) codes for outcomes and independent variables used in the study, are provided in the Appendix II.1. The details of cost estimation methods are provided in Appendix II.2.

2.2.3.2 Comparison groups

This study compared two main groups: Non-immigrants who were either born in or resided in Manitoba before the creation of the Registry in 1970 or were born in another Canadian province and registered in the Registry between January 1985 and December 2021. Immigrants were born outside Canada and obtained their permanent residence in Canada between January 1985 and March 2017. Immigrants were further classified based on their immigration characteristics, including refugees and non-refugees, years since immigration (1-10, 11-20, and 20+ years), primary and secondary immigrants, and region of birth (Africa, America and Oceania, Asia, and Europe).

2.2.3.3 Socio-demographic and other variables

Regressions were adjusted for relationship status, urban or rural residence, neighborhood income quintile, employment and income assistance, rent assistance, Charlson Comorbidity Index, causes and place of death, and year of death. Additionally, regression analyses restricted to immigrants were adjusted for age groups, sex, immigrant status (primary/secondary, refugee/non-refugee), years since immigration, and region of origin.

2.2.4 Matching Criteria

Non-immigrants were matched to immigrants based on sex, age at death and year of death using a ± 1 year window and a 2:1 matching ratio to compare EOL HC between these two groups. To analyze variation in EOL healthcare costs among immigrants according to their immigration characteristics, no matching was needed, as this was examined internally.

2.2.5 Statistical Analysis

The zero-inflated gamma model was used to assess mean differences in EOL healthcare costs. Since 3.71% of decedents had zero healthcare costs due to factors such as accidental death or the snowbird effect, the Zero-Inflated Gamma Model with a gamma distribution and log link under the hurdle procedure addressed both zero and non-zero healthcare costs through two separate regressions (Nobre et al., 2017; Costa et al., 2021; Lee et al., 2010; Mullahy, 1986). Quantile regression (Koenker and Hallock, 2021) was used to examine variations in end-of-life healthcare costs at different levels of the cost distribution while adjusting for other covariates (Cook and Manning, 2009; Olsen et al., 2017). All analyses were conducted using SAS software 9.4 © (SAS Institute, Cary, NC, USA).

2.3 Results

2.3.1 Descriptive Statistics

In the analytic sample (Table 2.1), 278 individuals (3.71%) did not have recorded costs. Among those who incurred costs were 2,469 immigrants and 4,741 non-immigrants, nearly 40% were married or had a common-law partner, 72% lived in urban areas, 10% received employment and income assistance, and around 60% had three or more comorbidities. The leading causes of death were frailty (35%), followed by terminal illness (32%), and around half of the individuals died in a hospital (56.4% of immigrants and 52.5% of non-immigrants). Urban residents (\$33,361), individuals with more comorbidities (\$38,416 for individuals with 5+ comorbidities), recipients of employment and income assistance (EIA) (\$32,266), rent assistance (\$35,985), and individuals who died in a hospital (\$32,914) experienced higher costs than rural residents, individuals with no comorbidities, those not receiving EIA and those who died outside of hospitals, respectively.

On average, the EOL cost per individual was \$29,623, with immigrants incurring higher expenses (\$43,961) than non-immigrants (\$22,156). Among immigrants, the average cost per person was highest for refugees (\$50,272), immigrants from Africa (\$62,524), and recent immigrants (1–10 years) (\$48,884).

Table 2.2 shows that, among those with cost data, 74.5% of immigrants used overnight hospital care in their last year of life, compared to 34% non-immigrants. Compared to non-immigrants, immigrants also had higher use of Emergency Departments, government drug prescriptions, home care and ICU, but lower long-term care use.

Immigrants incurred higher average inpatient hospital costs (\$33,518) than non-immigrants (\$11,182). However, non-immigrants had a higher average per-person LTC cost (\$5,597) compared to immigrants (\$1,577). In addition, immigrants incurred a higher average per-person government-funded home care costs (\$1,409 vs \$393), physician and diagnostic tests costs (\$4,340 vs \$2,546), emergency department care costs (\$302 vs \$120) and government-funded drug costs (\$2,365 vs \$1,939).

2.3.2 Comparison of healthcare costs between immigrants and non-immigrants

Figure 2.1 shows that immigrants had significantly higher overall HC at EOL (aMD \$16,939; 95% CI \$14,473, \$19,404) than non-immigrants. The gap in EOL HCs between immigrants and non-immigrants was larger among males (aMD \$17,574; 95% CI \$14,091, \$21,056) than females (aMD \$15,550; 95% CI \$12,261, \$18,838) (p-value for interaction = 0.02). The gap in EOL healthcare costs between immigrants and non-immigrants widened with a higher number of comorbidities, from an average difference of \$4,051 (95% CI \$547, \$7,554) for

Table 2.1: Socio-demographic characteristics and average healthcare costs (AC) of healthcare users during the last year of life, January 2004–March 2022

Characteristics	All			Immigrants			Non-Immigrants		
	N	%	AC (C\$)	N	%	AC (C\$)	N	%	AC (C\$)
All*	7488	100		2582	34.5		4906	65.5	
had healthcare costs*	7210	100	29623	2469	34.2	43961	4741	65.8	22156
Age at Death									
50 - 54	562	7.8	25639	205	8.3	45857	357	7.5	14030
55 - 59	629	8.7	27608	217	8.8	45895	412	8.7	17976
60 - 64	670	9.3	31392	240	9.7	51037	430	9.1	20427
65 - 69	708	9.8	32340	241	9.8	53396	467	9.9	21473
70 - 74	784	10.9	29839	265	10.7	49131	519	11.0	19989
75 - 79	944	13.1	29907	321	13.0	47702	623	13.1	20738
80 - 84	1060	14.7	29592	363	14.7	41160	697	14.7	23567
85 - 89	986	13.7	30072	334	13.5	36901	652	13.7	26574
90 - above	867	12.0	29106	283	11.5	29910	584	12.3	28716
Sex									
Male	3708	51.4	28924	1284	52.0	44337	2424	51.1	20761
Female	3502	48.6	30363	1185	48.0	43554	2317	48.9	23616
Having Married/ Common-Law Partner									
Yes	2872	39.8	29112	1166	47.2	44826	1706	36.0	18372
No	4338	60.2	29961	1303	52.8	43187	3035	64.0	24283
Residence									
Rural Residence	2023	28.1	20040	267	10.8	35590	1756	37.0	17675
Urban Residence	5187	71.9	33361	2202	89.2	44976	2985	63.0	24792
Comorbidity Index									
0	747	10.4	10113	249	10.1	8345	498	10.5	10997
1 - 2	2163	30.0	22435	709	28.7	25571	1454	30.7	20905
3 - 4	1407	19.5	32953	455	18.4	47079	952	20.1	26202
5 - above	2893	40.1	38416	1056	42.8	63363	1837	38.7	24075
Cause of Death									
Sudden Death	304	4.2	19988	85	3.4	30845	219	4.6	15775
Terminal illness	2341	32.5	29056	794	32.2	45804	1547	32.6	20460
Frailty	2538	35.2	29468	838	34.0	41605	1700	35.9	23485
Other	1809	25.1	34010	606	24.5	53762	1203	25.4	24060
Not in Vital Statistics	218	3.0	14543	146	5.9	14414	72	1.5	14805
Employment/ Income Assistance									
Yes	696	9.7	32266	224	9.1	53818	472	10.0	22038
No	6514	90.3	29341	2245	90.9	42977	4269	90.0	22169
Rent Assistance									
Yes	487	6.8	35985	259	10.5	45046	228	4.8	25693
No	6723	93.2	29162	2210	89.5	43834	4513	95.2	21977

Characteristics	All			Immigrants			Non-Immigrants		
	N	%	AC (C\$)	N	%	AC (C\$)	N	%	AC (C\$)
Neighborhood income level									
Quintile 1	1828	25.4	30908	662	26.8	44862	1166	24.6	22985
Quintile 2	1391	19.3	28915	451	18.3	43170	940	19.8	22075
Quintile 3	1349	18.7	28440	419	17.0	48945	930	19.6	19201
Quintile 4	1161	16.1	28697	432	17.5	42525	729	15.4	20503
Quintile 5	974	13.5	30131	377	15.2	43909	597	12.6	21431
Quintile NF	507	7.0	31227	128	5.2	30773	379	8.0	31381
Location of Death									
Hospital	3881	53.8	32914	1393	56.4	59104	2488	52.5	18250
Out of Hospital	3329	46.2	25787	1076	43.6	24356	2253	47.5	26469
Immigration Characteristics of the Immigrant Population									
Refugee									
Yes				390	13.0	50272			
No				2609	87.0	43956			
Secondary Immigrant									
No				2554	85.0	45199			
Yes				445	15.0	42357			
Region of Origin									
Asia				1752	58.0	44526			
Europe				723	24.0	41458			
Africa				140	5.0	62524			
America and Oceania				384	13.0	45700			
Years Since Immigration									
1 - 10				628	21.0	48884			
11 - 20				1013	34.0	44314			
21 and more				1358	45.0	43223			

* The first two rows represent row% and the remainder column %

individuals with 1-2 comorbidities to \$38,874 (95% CI \$34,128, \$43,619) for those with 5 or more (p value for interaction <0.0001).

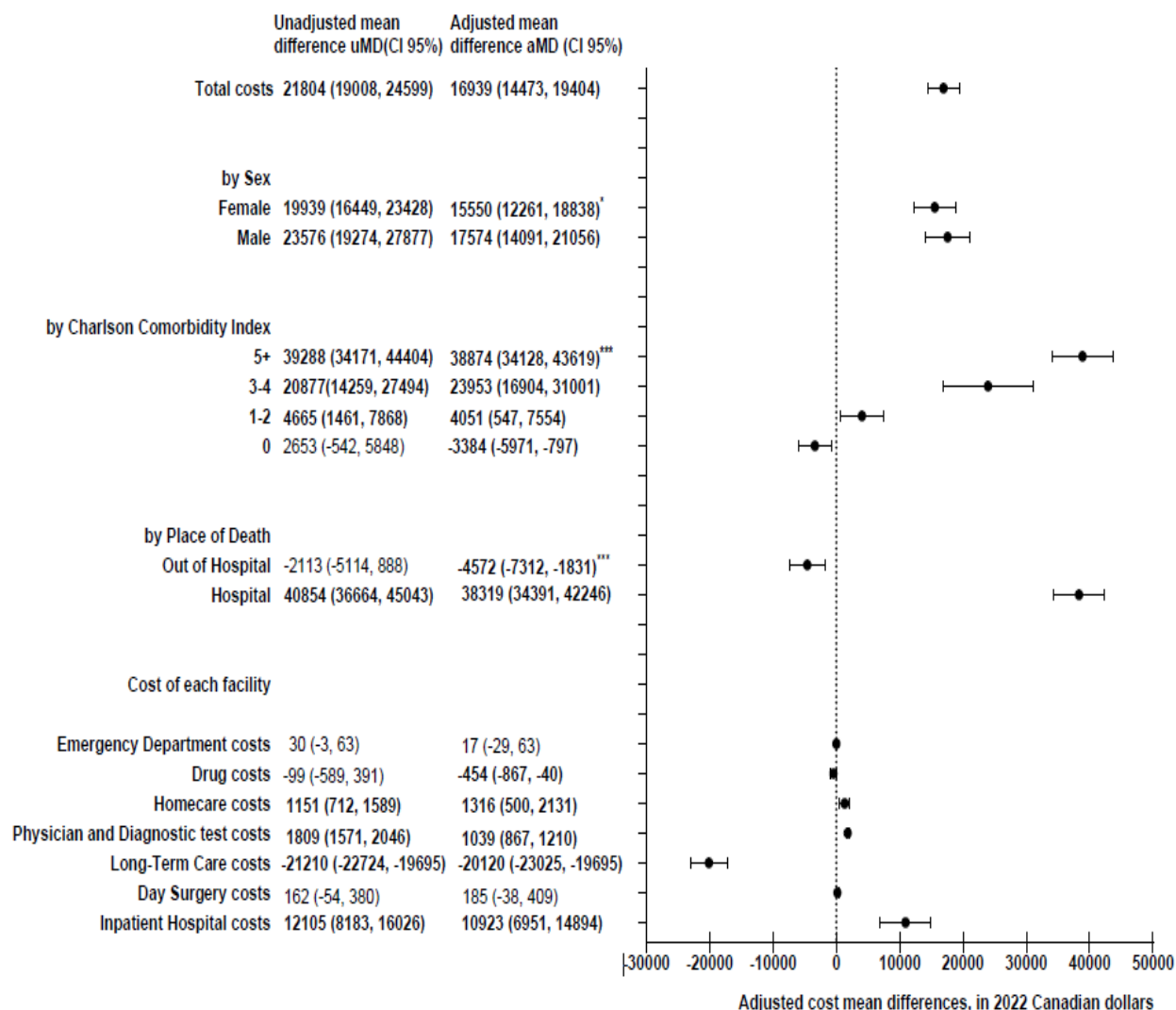
Table 2.2: The proportion of immigrants and non-immigrants utilizing various healthcare services and average costs during their final year of life, Manitoba, Canada, 2005-2022

	Immigrants		Non-Immigrants		P-value of chi sq
	%	AC (\$)	%	AC (\$)	
Inpatient hospital care	74.5	33518	34.0	11182	<0.0001
Intensive Care Unit (ICU) admissions among inpatients	19.0		3.0		<0.0001
Day Surgery care	21.0	448	19.0	377	0.06
Long-term care (LTC)	10.0	1577	15.0	5597	<0.0001
Home care	27.5	1409	10.0	393	<0.0001
Government-funded Drugs	71.0	2365	56.0	1939	<0.0001
Physician visit and diagnostic test	99.5	4340	99.0	2546	0.44
Emergency Department Care	65.0	302	27.6	120	<0.0001

Among those without comorbidities, immigrants spent less (aMD: -\$3,384; 95% CI: -\$5,971, -\$797) than non-immigrants. Compared to non-immigrants, the overall EOL costs of immigrants were significantly larger for those who died in hospital (aMD: \$38,319; 95% CI: \$34,391, \$42,246) but lower for those who died out of hospital (aMD: -\$4572; 95% CI: -\$7312, -\$1831) (p value for interaction <0.0001). Regression analyses conducted separately by cost source (Figure 2.1, bottom) show that immigrants had higher inpatient hospital costs (\$10,923; 95% CI: \$6,951, \$14,894), physician and diagnostic test costs (\$1,039; 95% CI: \$867, \$1,210), and homecare (\$1,316; 95% CI: \$500, \$2,131) costs and lower long-term care costs (-\$20,120; 95% CI: -\$23,025, -\$19,695) than non-immigrants among service users.

Figure 2.2 shows that the gap in EOL healthcare costs between immigrants and non-immigrants widened with increasing costs, from the 10th percentile (\$2,782; 95% CI \$2,619, \$2,945) to the 99th percentile (\$96,086; 95% CI \$68,456, \$123,716). Analyses by sex show that the cost differences between immigrants and non-immigrants increased toward the higher end of the cost distribution regardless of sex, and the dispersion was wider among males (Appendix II.3).

Figure 2.1: Mean differences in health care expenditure in the EOL between immigrants and non-immigrants



Matching was conducted based on sex, age at the time of death, and year of death. *** = $P < 0.001$ and * = $P < 0.05$ are the p-values of the interaction term with immigration status.

The zero-inflated log-gamma regressions adjusted for married or having partner (yes/no), income quintiles, employment and income assistance (yes/no), rent assistance (yes/no), residence (urban or rural), comorbidity index, causes of death, place of death and year of death. Distinct models were employed to examine the interactions among sex, place of death, and the Charlson comorbidity index with immigration status (one interaction term at a time) to get P-values for the Type III tests of fixed effects. The stratified models and regressions for the cost of each facility were adjusted for the variables of the main regression.

Appendices II.4 and II.5 indicate that among decedents who did not have any LTC stay in the last year of life, immigrants exhibited 10.32 times higher odds of hospitalization compared to non-immigrants (aOR: 10.32; 95% CI: 8.91, 11.96). In contrast, among those with at least one LTC stay, immigrants had 3.29 times higher odds of hospitalization (aOR: 3.29; 95% CI: 2.36–4.58). This suggests the association between immigration status and hospitalization was weaker for individuals with an LTC stay than for those without. Additionally, the interaction between immigration status and LTC stay was statistically significant, providing compelling evidence that LTC status modifies the relationship between immigration status and hospitalization.

2.3.3 Healthcare costs in the EOL among immigrant sub-groups

Figure 2.3 shows that, apart from years since immigration and sex, immigration characteristics had no significant impact on EOL HCs among immigrants. Recent immigrants (≤ 10 years) incurred significantly higher costs (aMD: \$5,626; 95% CI: \$249, \$11,002) than those who had been in Canada for over 20 years. EOL HCs were significantly lower among males (aMD: -\$4,036; 95% CI: -\$7,590 to -\$481) compared to females. The descriptive statistics in Appendix II.6 show that, except for day surgery care and ICU care, the percentages of users and costs for inpatient care, LTC, home care, and ED care were significantly higher for females than for males.

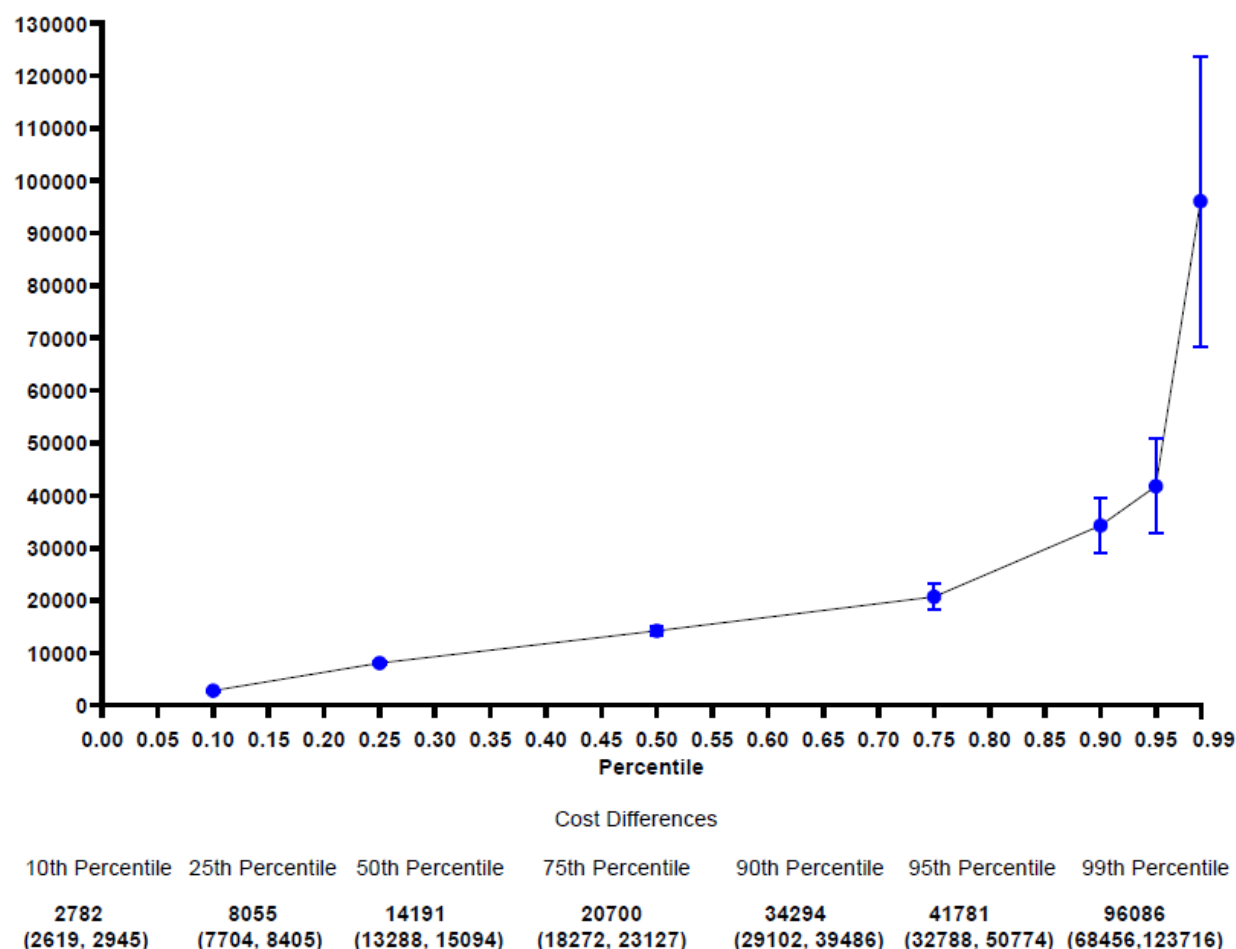
2.4 Discussion

2.4.1 Main Findings

Our matched study showed that immigrants incur significantly higher overall EOL healthcare expenses compared to non-immigrants, primarily driven by higher utilization of acute care services, including hospitalizations. These differences are particularly evident among individuals with a higher number of comorbidities and those who died in hospitals. Immigrants

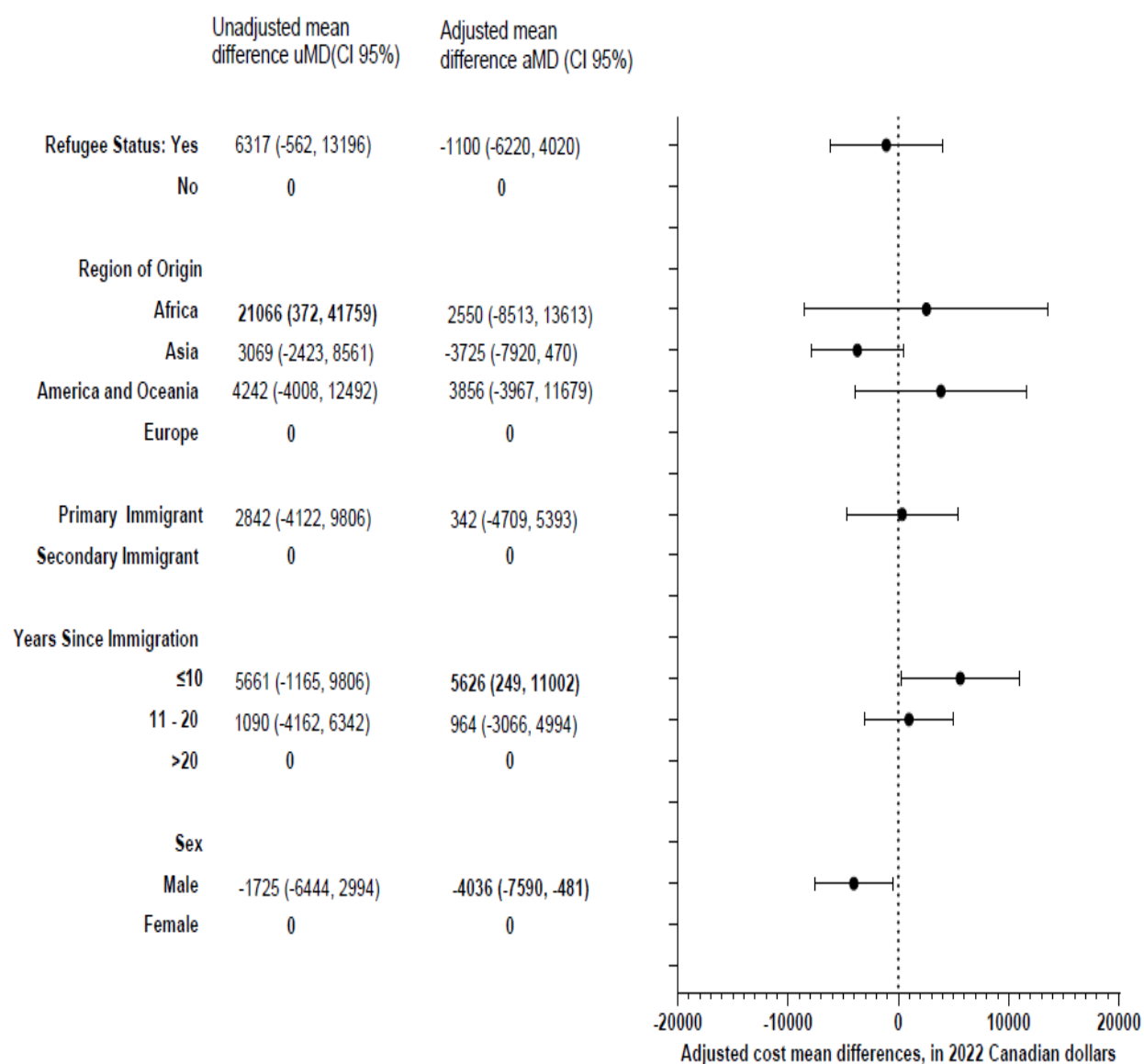
had higher costs for hospital and home care but lower costs for long-term care than non-immigrants. Among immigrants, recent immigrants and females incurred higher EOL HCs than those who had been in Canada for 20 years or more, and males, respectively.

Figure 2.2: The estimated differences in healthcare expenditure in the EOL between immigrants and non-immigrants (adjusted) using Quantile regression



Adjusted for relationship status, residence, comorbidity index, place of death, neighborhood income quintiles, causes of death, employment and income assistance, rent assistance, and year of death.

Figure 2.3: Mean differences in health care expenditure in the last year of life between immigrant subgroups



The regression was adjusted for age at death, married or having partner, income quantiles, causes of death, employment and income assistance, rent assistance, urban or rural residence, knowledge of English or French at immigration, and year of death.

2.4.2 Limitations

This study examines EOL healthcare expenditures within the last year of death only and does not capture immigrants' lifetime healthcare utilization and costs. Findings should not be generalized outside the last year of life. The findings may not be generalizable to temporary

residents because they were not included in the study. Additionally, due to data constraints, this study could not include individuals living outside Canada in their last year of life. Furthermore, the study did not account for out-of-pocket healthcare expenses incurred in the last year of life, particularly drug costs. Drugs used in hospitals, nursing stations, ward stock, and outpatient visits at Cancer Care Manitoba were excluded from drug costs, as this information was not available in the drug program information network dataset. However, medications administered to patients during overnight stays or day surgeries in the hospital were accounted for in the calculation of hospital costs. Due to the lack of records of actual costs, the average cost per day for EOL home care and per visit to the emergency department was calculated. Finally, as Manitoba has a universal coverage model, the study's findings may not be broadly applicable to populations in other healthcare systems.

2.4.3 Interpretation

This matched study found that overall end-of-life (EOL) care expenses in Manitoba were significantly higher for immigrants than for non-immigrants, driven primarily by higher costs for acute care including overnight hospitalizations and to a lesser extent higher utilization of home care, physician and diagnostic testing, despite significantly lower long-term care utilization and costs.

Findings also revealed that immigrants had lower costs than non-immigrants among individuals without comorbidities, and a higher proportion of immigrants used emergency department care. These findings may reflect healthcare utilization patterns among immigrants, often characterized by access barriers that may delay routine care (Cook and MWG, 2009; CIHI, 2025), limited engagement with long-term care, and waiting for additional comorbidities to develop or symptoms to appear more severe (Shugarman et al., 2008; Kelly et al., 2010).

This study also found that a higher percentage of immigrants were hospitalized and deceased in the hospital during their last year of life, subsequently resulting in a significant gap in EOL HC between immigrants and non-immigrants. This gap is wide among the high-cost patients. Barriers to utilizing routine care earlier in life may contribute to more comorbidities and adverse health outcomes (Katsuragawa et al., 2022; Pati et al., 2023; Shi, 2012; Wang et al., 2012) that may necessitate more complex inpatient care at EOL and, ultimately, increase EOL care costs (Pandey et al., 2021; Shrestha et al., 2023; Sudha, 2014). This aspect is consistent with previous research findings that immigrants are more likely to receive aggressive care in acute settings during their EOL (Chu et al., 2021; Quach et al., 2021; Yarnell et al., 2017).

Several factors may contribute to the underutilization of primary and preventative care among immigrants in their acculturation stage, including language barriers, transportation challenges, prolonged waiting times, lower health literacy, and difficulties in integration (Fuller-Thomson, 2011; Pandey et al., 2021, 2022; Yarnell et al., 2020). These challenges may be harder for immigrants arriving later in life and in old age. Lower levels of education and economic disadvantages experienced earlier in life may contribute to lower healthcare utilization, adding to the accumulation of multiple morbidities in adulthood (Chandrasekar et al., 2023; Pati et al., 2023; Taylor & Demakakos, 2024).

The finding that immigrants utilize long-term care facilities significantly less than non-immigrants aligns with recent studies indicating that a relatively small number of immigrants reside in such establishments, including personal care homes and nursing homes (WHO, 2018). More research is needed to understand why immigrants use more hospital EOL care and rely less on long-term care facilities (LTC). This study found that immigrants were more likely than non-immigrants to receive government-funded home care and had higher home care costs in their last

year of life. Furthermore, they may prefer informal care, including care from family members (Qureshi et al., 2021), who may regard their caregiving responsibilities as both a filial obligation and a cultural norm (Ahmad et al., 2020; Shrestha et al., 2023; Sudha, 2014). Additionally, longer wait times for placement in LTC facilities among immigrants compared with non-immigrants may further deter them from seeking LTC homes (Qureshi et al., 2021; Quach et al., 2021).

This study also found that among immigrants, females incurred higher EOL HC than males. This finding is consistent with studies indicating that females are more likely to use home health services, nursing home care, and hospice services during EOL care (Kelly et al., 2010; Narayanan et al., 2025; Shugarman et al., 2008).

2.4.4 Implications for public health interventions, practices, and policies and future research

Since hospital costs are the main driver of differences in EOL healthcare costs between immigrants and non-immigrants, and the proportion of emergency department users and associated costs is substantial, while healthcare costs for immigrants without comorbidities tend to be lower than those for non-immigrants, the most important implication is to promote the routine use of healthcare services among immigrants to prevent deterioration of health and escalation of disease severity later in life. In addition, these findings highlight the importance of initiating early discussions among healthcare providers, patients, and their families regarding available healthcare options, including palliative care facilities and their benefits, while respecting patients' preferences and health status.

Future research

Further investigation using longitudinal research should follow immigrants and non-immigrants from the start of immigrants' health insurance coverage through the end-of-life, or over a longer period, to better understand patterns of healthcare utilization and health, and how these patterns and costs evolve over time in both groups. In addition, surveys or qualitative studies are warranted to elucidate why immigrants delay healthcare utilization prior to EOL.

2.5 Conclusion

This study found that immigrants faced considerably higher EOL healthcare costs compared to non-immigrants. The difference in EOL HC was driven by a higher proportion of immigrants being hospitalized, higher costs per hospitalization, particularly among those with more comorbidities, and dying in hospitals, despite lower long-term care costs, which aligns with research on immigrants' underutilization of primary and preventative care, suggesting opportunities for cost-savings through earlier intervention.

2.6 References

Ahmad M, Van Den Broeke J, Saharso S, Tonkens E, Bowers BJ. (2020). Persons with a Migration Background Caring for a Family Member with Dementia: Challenges to Shared Care. *Gerontologist*, 60(2):340–349.

Canadian Institute for Health Information. (2017). *Canada's seniors' population outlook: Uncharted territory*.

Canadian Institute for Health Information. (2022). *Introduction to CMG+ Aggregation Variables*. Ottawa, ON.

Canadian Institute for Health Information. (2002). *Resource Indicators: DAD Resource Intensity Weights and Expected Length of Stay*.

Canadian Institute for Health Information. (2024). *Measuring primary care access through emergency department use*. Accessed February 13, 2026.

- Chandrasekar R, Lacey R E, Chaturvedi N, Hughes AD, Patalay P, Khanolkar A R. (2023). Adverse childhood experiences and the development of multimorbidity across adulthood, a national 70-year cohort study. *Age Ageing*, 52(4).
- Chu A, Barbera L, Sutradhar R, Oz U E, O’Leary E, Seow H. (2021). Association between end-of-life cancer care and immigrant status: A retrospective cohort study in Ontario, Canada. *BMJ Open*, 11(6).
- Ciupitu-Plath C C, Gohl D, Kofahl C. (2014). Migration and Health Care Utilization in the European Context. *Springer New York*, 145–169 p.
- Cook B L, Manning W G. (2009). Measuring Racial/Ethnic Disparities across the Distribution of Health Care Expenditures. *Health Serv Res*, 44(5p1):1603-21.
- Costa E de E, Schneider S, Carlotto G B, Cabalheiro T, Júnior M R de O. (2021). Zero-inflated-censored Weibull and gamma regression models to estimate wild boar population dispersal distance. *Japanese Journal of Statistics and Data Science*, 4(2):1133–1155.
- Constant, A. F., Garcia-Munoz, T., Neuman, S., & Neuman, T. (2017). A “healthy immigrant effect” or a “sick immigrant effect”? Selection and policies matter. *The European Journal of Health Economics*, 19(1), 103–121.
- Duncan I, Ahmed T, Dove H, Maxwell T L. (2019). Medicare cost at end-of-life. *American Journal of Hospice and Palliative Medicine*, 36(8):705–710.
- Finlayson G, Ekuma O, Yogendran M, Burland E, Forget E. (2010). *The Additional Cost of Chronic Disease in Manitoba*. Winnipeg, MB. Manitoba Centre for Health Policy.
- Fortuna L R, Porche M V., Alegria M. (2008). Political violence, psychosocial trauma, and the context of mental health services use among immigrant Latinos in the United States. *Ethn Health*, 13(5):435–63.
- Fowler R, Hammer M. (2013). End-of-Life Care in Canada. *Clinical and Investigative Medicine*, 36(3): E127-32.
- Fuller-Thomson, E., Noack, A. M., & George. U. (2011). Health Decline Among Recent Immigrants to Canada: Findings from a Nationally Representative Longitudinal Survey. *Canadian Journal of Public Health*, 4(102), 273–280
- Goettler A. (2020). What Happens to the Healthy Immigrant Later in Life? The health of (Forced) Migrants Through the Life Course. In *Health in Diversity – Diversity in Health*, 103–19.
- Hall E, Cuellar NG. (2011). Immigrant Health in the United States: A Trajectory Toward Change. *Journal of Transcultural Nursing*. SAGE Publications Inc, 27(6): p. 611–626.
- Jatrana S, Pasupuleti S R, Richardson K. (2014). Nativity, duration of residence and chronic health conditions in Australia: Do trends converge towards the native-born population? *Soc Sci Med*, 119:53–63.

- Johnson LM, Richards J, Pink GH, Campbell L. (1998). Case Mix Tools for decision making in health care. Canada Institute for Health Information.H118-95/1998E.
- Katsuragawa S, Goto A, Tsurutani Y, Fukuma S, Inoue K. (2022). No Healthcare Utilization and Death. *J Gen Intern Med*, 37(7):1648–1657.
- Koenker R, Hallock K F. (2001). Quantile Regression. *Journal of Economic Perspectives*, 15(4):143-156.
- Kelly A, Conell-Price J, Covinsky K, Cenzer I S, Chang A, Boscardin W J, et al. (2010). Length of stay for older adults residing in nursing homes at the end-of-life. *J Am Geriatr Soc*, 58(9):1701–6.
- Lee AH, Zhao Y, Yau KKW, Xiang L. (2010). How to analyze longitudinal multilevel physical activity data with many zeros? *Prev Med*, 51(6):476–81.
- Lees C S, Seow H, Chan K K W, Gayowsky A, Merchant S J, Sinnarajah A. (2024). Sex-Based Analysis of Quality Indicators of End-of-Life Care in Gastrointestinal Malignancies. *Current Oncology*, 31(3):1170–1182.
- Lubitz J D, & Riley G F. (1993). Trends in Medicare payments in the last year of life. *N Engl J Med*, 328:1092–6.
- Markides, K.S., and Gerst, K. (2011). *Immigration, aging, and health in the U.S.* In: Settersten, Richard A., Angel, Jacqueline L., editors. *Handbook of the sociology of aging*. New York: Springer; 2011. p. 103–16.
- Marmot M, Bell R. (2012). Fair society, healthy lives. *Public Health*, 126(SUPPL.1):4-10.
- Menec V, Lix L et al. (2004). *Patterns of health care use and cost at the end-of-life*. Manitoba Centre for Health Policy.
- Mullahy J. (1986). Specification and testing of some modified count data models. *Journal of Econometrics*.1986. 33(3):341-365.
- Narayanan D, Chandrasekaran A S, Raj S E A, Vyas N. (2025). Gender disparities in end-of-life care: A scoping review of patient, caregiver and care provider perspectives in low-and middle-income countries. *BMC Palliat Care*, 24(1):62.
- Nobre A A, Carvalho M S, Griep R H. (2017). Fonseca M de J M da, Melo E C P, Santos I de I, et al. Multinomial Model and Zero-Inflated Gamma Model To Study Time Spent On Leisure Time Physical Activity: An Example Of Elsa-Brasil. *Rev Saude Publica*, 51:76.
- Needham D M, Bronskill S E, Calinawan J R, Sibbald W J, Pronovost P J, Laupacis A. Projected incidence of mechanical ventilation in Ontario to 2026: Preparing for the aging baby boomers. *Crit Care Med*. 2005;33(3):574–9.
- Olsen M A, Tian F, Wallace A E, Nickel K B, Warren D K, Fraser V J, et al. (2017). Use of quantile regression to determine the impact on total health care costs of surgical site infections following common ambulatory procedures. *Ann Surg*. 2017;265(2):331–339.

- Pandey M, Kamrul R, Michaels C R, McCarron M. (2022). Identifying Barriers to Healthcare Access for New Immigrants: A Qualitative Study in Regina, Saskatchewan, Canada. *J Immigr Minor Health*. 2022;24(1):188–198.
- Pandey M, Maina R G, Amoyaw J, Li Y, Kamrul R, Michaels C R, et al. (2021). Impacts of English language proficiency on healthcare access, use, and outcomes among immigrants: a qualitative study. *BMC Health Serv Res*. 2021;21(1):741.
- Pati S, Sinha A, Verma P, Kshatri J, Kanungo S, Sahoo K C, et al. (2023). Childhood health and educational disadvantage are associated with adult multimorbidity in the global south: Findings from a cross-sectional analysis of nationally representative surveys in India and Brazil. *J Epidemiol Community Health*, 77(10):617–624.
- Quach B I, Qureshi D, Talarico R, Hsu A T, Tanuseputro P. (2021). Comparison of End-of-Life Care Between Recent Immigrants and Long-standing Residents in Ontario, Canada. *JAMA Network Open*, 4(11): e2132397.
- Qureshi D, Schumacher C, Talarico R, Lapenskie J, Tanuseputro P, Scott M, et al. (2021). Describing Differences Among Recent Immigrants and Long-Standing Residents Waiting for Long-Term Care: A Population-Based Retrospective Cohort Study. *J Am Med Dir Assoc*, 22(3):648–655.
- Sangalang C C, Becerra D, Mitchell F M, Lechuga-Peña S, Lopez K, Kim I. (2019). Trauma, Post-Migration Stress, and Mental Health: A Comparative Analysis of Refugees and Immigrants in the United States. *J Immigr Minor Health*, 21(5):909–919.
- Shi L. (2012). The Impact of Primary Care: A Focused Review. *Scientifica (Cairo)*. 2012;201
- Shrestha S, Arora S, Hunter A, Debesay J. Changing dynamics of caregiving: a meta-ethnography study of informal caregivers' experiences with older immigrant family members in Europe. *BMC Health Serv Res*. 2023;23(1):43
- Shugarman L R, Bird C E, Schuster C R, Lynn J. (2008). Age and Gender Differences in Medicare Expenditures and Service Utilization at the End-of-life for Lung Cancer Decedents. *Women's Health Issues*, 18(3):199-209.
- Song Z, Ferris TG. (2018). Baby Boomers and Beds: a Demographic Challenge for the Ages. *J Gen Intern Med*, 33(3):367–9.
- Spall H G C V, Hill A D, Fu L, Ross H J, Fowler R A. (2021), Temporal trends and sex differences in intensity of healthcare at the end-of-life in adults with heart failure. *J Am Heart Assoc*, 10(1):1–18.
- Sudha S. (2014). Intergenerational Relations and Elder Care Preferences of Asian Indians in North Carolina. *J Cross Cult Gerontol*, 29(1):87–107.
- Tanuseputro P, Wodchis W P, Fowler R, Walker P, Bai Y Q, Bronskill S E, et al. (2015). The health care cost of dying: A population-based retrospective cohort study of the last year of life in Ontario, Canada. *PLoS One*, 10(3).

- Taylor K, Demakakos P. (2024). Adverse childhood experiences and trajectories of multimorbidity in individuals aged over 50: Evidence from the English Longitudinal Study of Ageing. *Child Abuse Negl*, 149.
- Van Spall, H. G. C., Hill, A. D., Fu, L., Ross, H. J., & Fowler, R. A. (2021). Temporal Trends and Sex Differences in Intensity of Healthcare at the End-of-life in Adults with Heart Failure. *Journal of the American Heart Association*, 10(1), Article e018495.
- Vang Z M, Sigouin J, Flenon A, Gagnon A. (2017). Are immigrants healthier than native-born Canadians? A systematic review of the healthy immigrant effect in Canada. *Ethn Health*, 22(3):209–41.
- Wang S-Y, Chen L-K, Hsu S H, Wang S-C. 2012. Health care utilization and health outcomes: A population study of Taiwan. *Health Policy Plan*, 27(7):590–9.
- WHO. *Health of older refugees and migrants*. Copenhagen; 2018.
- Yarnell C J, Fu L, Bonares M J, Nayfeh A, Fowler R A. (2020). Association between Chinese or South Asian ethnicity and end-of-life care in Ontario, Canada. *CMAJ*, 192(11): E266–274.
- Yarnell C J, Fu L, Manuel D, Tanuseputro P, Stukel T, Pinto R, et al. (2017). Association between immigrant status and end-of-life care in Ontario, Canada. In: *JAMA - Journal of the American Medical Association*. American Medical Association, 318(15). p. 1479–1488.

Appendix II.1 list of variables

Variables	Definition	Data Source	ICD-10/ ICD-10-CA /Categories
Main Study Outcome: Total Cost	Total costs include direct government expenses for physician services, inpatient hospital care, day surgery, emergency department visits, long-term care, home care, and drug costs incurred during the individual's last year of life.	Data sources and cost calculation methods are outlined in the Cost Calculation Methods section (Appendix II.II) for each healthcare facility.	
Immigration Status	Immigrants are individuals who were born outside of Canada and landed in Canada between January 1985 and March 2017.	The Immigration, Refugee and Citizenship Canada Permanent Resident database	Immigration Status categories are : Immigrants Non-immigrants
	Non-immigrants are individuals who were either born in Manitoba or lived in Manitoba prior to the establishment of the Manitoba health insurance registry in 1970. Additionally, non-immigrants include those who were born in other provinces of Canada and moved to Manitoba between January 1985 and December 2021. Non-immigrants are the reference group in the regression analysis.	Manitoba health insurance registry	
Age	Age at the date of death.	Manitoba health insurance registry	Categories of Age at death are: 50 – 54,55 – 59,60 – 64,65 – 69,70 – 74,75 – 79, 80 – 84,85 – 89, 90 - above
Sex	Sex is classified as male and female. The female group is used as the reference category in the regression analysis among immigrants.	Manitoba health insurance registry	Sex categories are: Male Female
Having Married/ Common-Law Partner	Having a spouse or common-law partner is determined by the last date before the last year of life. It is categorized as either yes or no. The reference group in the regression analysis is yes.	Manitoba health insurance registry	Having Married/ Common-Law Partner categories are: Yes No
Residence	Residence is defined as the location (rural or urban in Manitoba) where the individual was living at the last date before the final year of life. Using the postal code, the residence was classified as Urban (Winnipeg and Brandon) or rural (all other RHAs).	Manitoba health insurance registry	Residence categories are: Urban Residence Rural Residence
Comorbidity Index	The Charlson comorbidity index classifies comorbidities by summing the weights of each comorbidity category for an individual. Using the Medical Service/Physician Claims and hospital abstract data, comorbidities were defined into 17 categories and assigned weights based on ICD-10-CA diagnosis codes.	Medical Service/Physician Claims & Hospital Abstract	Comorbidity Categories are: 0 1-2 3-4 5-above

	Comorbid Condition	Weight	ICD-10-CA Codes	
	Myocardial Infarction	1	I21, I22, I25.2	
	Congestive Heart Failure	1	I09.9, I11.0, I13.0, I13.2, I25.5, I42.0, I42.5–I42.9, I43, I50, P29.0	
	Peripheral Vascular Disease	1	I70, I71, I73.1, I73.8, I73.9, I77.1, I79.0, I79.2, K55.1, K55.8, K55.9, Z95.8, Z95.9	
	Cerebrovascular Disease	1	G45, G46, H34.0, I60–I69	
	Dementia	1	F00–F03, F05.1, G30, G31.1	
	Chronic Pulmonary Disease	1	I27.8, I27.9, J40–J47, J60–J67 J68.4, J70.1, J70.3	
	Connective Tissue Disease Rheumatic Disease	1	M05, M06, M31.5, M32–M34, M35.1, M35.3, M36.0	
	Mild Liver Disease	1	B18, K70.0–K70.3, K70.9, K71.3–K71.5, K71.7, K73, K74, K76.0, K76.2–K76.4, K76.8, K76.9, Z94.4	
	Diabetes without Chronic Complications	1	E10.0, E10.1, E10.6, E10.8, E10.9, E11.0, E11.1, E11.6, E11.8, E11.9, E12.0, E12.1, E12.6, E12.8, E12.9, E13.0, E13.1, E13.6, E13.8, E13.9, E14.0, E14.1, E14.6, E14.8, E14.9	
	Diabetes with Chronic Complications	2	E10.2–E10.5, E10.7, E11.2–E11.5, E11.7, E12.2–E12.5, E12.7, E13.2–E13.5, E13.7, E14.2–E14.5, E14.7	
	Paraplegia and Hemiplegia	2	G04.1, G11.4, G80.1, G80.2, G81, G82, G83.0–G83.4, G83.9	
	Renal Disease	2	I12.0, I13.1, N03.2–N03.7, N052–N05.7, N18, N19, N25.0, Z49.0–Z49.2, Z94.0, Z99.2	
	Cancer	2	C00–C26, C30–C34, C37–C41, C43, C45–C58, C60–C76, C81–C85, C88, C90–C97	
	Moderate or Severe Liver Disease	3	I85.0, I85.9, I86.4, I98.2, K70.4, K71.1, K72.1, K72.9, K76.5–K76.7	
	Metastatic Carcinoma	6	C77–C80	
	HIV/AIDS	6	B20–B22, B24	
Cause of Death	The information on the causes of death was grouped using the International Classification of Diseases (ICD-10).		Vital Statistics Mortality Registry	ICD-10 codes are categorized into the following categories: 1. Sudden Death (S00-T98, V01-Y98), 2. Terminal illness (C00-D48, N00-N99, B20-B24), 3. Frailty (F00-F03, G00-G99, I00-I49 & I51-I99, J09 – J18) and 4. Other (I50, J40 -J47, and the remaining codes of ICD-10). The individuals whose information

			was not recorded in the Vital Statistics dataset are categorized as Not in Vital Statistics.
Employment and Income Assistance (EIA)	The individuals who received employment and income assistance from the provincial employment and income assistance program to meet basic personal and family needs at the last date before the EOL are categorized as yes. The rest of the individuals are categorized as no.	Social Allowances Management Information Network (SAMIN)	EIA Categories are: Yes No
Rent Assistance	The low-income seniors, families, and individuals with disabilities who received financial benefits to pay for housing at the last date before the last year of life are categorized as yes. The rest of the individuals are categorized as no.	Social Housing Rental Aid	Rent Assistance Categories are: Yes No
Neighborhood Income Quintiles (NIQ)	The income quintile is a measure of a neighborhood's socioeconomic status that divides individuals from both distinct groups (urban and rural) into five income categories based on the average household income at the neighborhood level from the census data, ranging from the lowest to the highest, with approximately 20% of the population in each group.	Manitoba health insurance registry, Canada Census data files, Postal Code Conversion file, and Manitoba Health Population file.	NIQ Categories are Quantile 1 (lowest) Quantile 2 Quantile 3 Quantile 4 Quantile 5 Quantile Not Found
Location of Death	The location of death was grouped into two categories: 1. Collected from hospital abstract records, it includes individuals who were in a hospital on the day of death and categorized as "Hospital". 2. Individuals who had no records in the hospital abstract on the day of death were classified as "out of hospital."	Hospital Abstract,	Location of Death categories are: 1. Hospital 2. Out of Hospital
Refugee	Refugee status is binary, either yes or no. Individuals who were granted permanent resident status through the Refugee Resettlement Programs, including Government-Assisted Refugees (GAR) and Blended Visa Office-Referred (BVOR), as well as those who sought protection at a port of entry or inland office due to fear of persecution if returned to their home country, are classified as refugees. Non-Refugee Immigrants are those who were granted permanent resident status based on their ability to contribute to Canada's economy (economic immigrants) or those who a Canadian citizen or permanent resident sponsored for the relationship as the parent, grandparent, spouse, partner or child (family class) or others who were selected for permanent resident status neither economic immigrants, family class nor refugee categories.	The Immigration, Refugee and Citizenship Canada Permanent Resident database	Refugee Status Categories are: Yes No
Primary or Secondary Immigrants	Immigrants who directly landed in Canada from their country of birth are classified as primary immigrants. Immigrants who landed in Canada from a country other	The Immigration, Refugee and Citizenship Canada	Primary or Secondary Immigrants categories are:

	than their country of birth are classified as secondary immigrants.	Permanent Resident database	Primary Immigrant Secondary Immigrant
Years Since Immigration	The years since immigration are calculated by subtracting the year of landing from the year of death. Based on the years since immigration, immigrants are grouped into the following three groups:	The Immigration, Refugee and Citizenship Canada Permanent Resident database, and the Manitoba health insurance registry	1-10: Immigrants who had been in Canada for no more than 10 years before their death. 11-20: Immigrants who had been in Canada for no more than 20 years before their death. 21 and more: Immigrants who had been in Canada for over 20 years before their death.
Region of Origin	Based on the birth country data of immigrants from permanent resident data, immigrants' region of origin is classified as follows: Asia (West Central Asia and the Middle East, Eastern Asia, Southeast Asia, Southern Asia) Europe (Western Europe, Eastern Europe, Northern Europe, Southern Europe) Africa (Western Africa, Eastern Africa, Northern Africa, Central Africa, Southern Africa) America and Oceania (North America, Central America, Caribbean and Bermuda, South America, and Oceania).	The Immigration, Refugee and Citizenship Canada Permanent Resident database	Region of Origin categories are: Asia Europe Africa America and Oceania

Appendix II.2 Methods of cost estimation

Hospitalization costs

The Manitoba Centre for Health Policy (MCHP) received admission and discharge records of inpatient, day surgery hospitalization, and clinical information from the hospital abstract dataset maintained by Manitoba Health. The records from January 2004 to March 2004 were received from the hospital abstracts user manual (HAUM), and the rest of the records (April 2004 to December 2022) were received from the discharge abstract database (DAD). Hospital records that fall within the study period (January 2004 to December 2022) were used to match hospital separation dates to identify hospital stays in the last year of life. Day surgery records were identified from the hospital abstract dataset using the transaction code, which is an ‘in-house’ variable of MCHP, to indicate whether the record is a day surgery case or an inpatient case (MCHP, 2003).

The hospitalization costs were calculated using the Resource Intensity Weight (RIW) for each hospital record assigned by the Canadian Institute for Health Information (CIHI). RIW represents the relative resource intensity used by a particular group compared to the average case, thus presenting different burdens on the healthcare resources used by different groups (Johnson et al., 1998). CIHI compiles groups of patients using their Case Mix Groups+ (CMG+) methodology, where patients are similar within the same group in terms of clinical and resource utilization characteristics and uses this information to assign RIW for each inpatient episode. To calculate the costs of day surgery, the Day Procedure Group (DPG) and the Comprehensive Ambulatory Classification System (CACS) were used by CIHI to group patients together into the same category with respect to homogenous clinical and resource utilization characteristics, and a day surgery RIW was assigned for each group (CIHI, 2009).

MCHP received RIWs from Manitoba Health as part of annual data requests in two ways: 1. directly attached to the hospital abstract dataset, and 2. a dataset of RIWs for five consecutive years with CMG+, where the same grouping methodology was used across all five-year records. The RIWs for inpatient hospitalization records for fiscal years 2003-2004 to 2013-2014 were received directly from the hospital abstract dataset. For the rest of the years, MCHP received RIWs from CIHI for each of the five consecutive years, where the same CMG+ methodology was used. The RIWs for day surgery records were received for each year from both sources (attached to outpatient records and a five-year dataset).

The Cost of Standard Hospital Stay (CSHS)/Cost per weighted case (CPWC) values for Manitoba for each year were received from CIHI, except for 2003-2004. For 2003-2004, CPWC was received from the work on the costing of Finlayson *et al.*, 2001. The CSHS includes intensive care unit care (ICU) costs and excludes physician compensation, as it varies within the hospital and across jurisdictions. Finally, the inpatient and day surgery hospital costs were calculated by multiplying the inpatient and day surgery RIWs by CSHS, respectively. The records of emergency department visits were not included in the hospitalization records because these visits were not recorded as hospital admissions.

The formula for inpatient costs of an individual in the last year of life: Inpatient (overnight stay) cost (individual stay/record) = CMG PLUS RIW for Inpatient* CSHS

The formula for day surgery (outpatient) costs of an individual in the last year of life: day surgery cost (individual record) = CMG PLUS RIW for outpatient* CSHS

Day Surgery cost

Day surgery cost (individual stay/record) = $DPG/CACS\ RIW * CSHS$. Individual day surgery costs were grouped into 12 separate months before the death date based on the day surgery service date. Total last year of life day surgery cost (per individual) = sum (month1 – month12 cost for day surgery per individual).

Physician service costs

The physician services and fee information were collected from the medical service (physician claims) dataset. The medical services data includes fee-for-service billing records for nearly all physician services, including patient contacts (visits), surgeries, anesthesia, and radiology. The physician service costs include ambulatory (out-of-hospital) services as well as some in-hospital services (physician consultations, limited laboratory services that are not funded by the hospital's global budget, anesthesia, and prosthetic services). Medical service providers submitted claims for services to Manitoba Health for reimbursement. MCHP received medical service information, including the service fee, demographic information, scrambled personal health identification number, and date of service, for individuals from Manitoba Health as part of the yearly data request. A small percentage of physicians are paid on a salary basis, and if they do not shadow-bill for each service, these records do not appear in the medical claims database. The records of missing diagnosis codes and the claims for dentist, chiropractor, and optometrist services were excluded. The fees paid to physicians were adjusted due to late entry or a retroactive change in the fee schedule, so the cost reflects the net fee paid by the Manitoba government to physicians for their services. Additionally, a geographic fee differential may be added to physician fees: 25% for Northern Manitoba, 5% for rural Manitoba and Brandon, and 0% for the city of Winnipeg and areas outside of Manitoba.

Physician service net fee claims for individuals were grouped into 12 separate months before death based on the date of service. Total last year of life government paid the net fee for an individual = sum (month1 – month12 cost for physician service for an individual by the government).

Drug costs

The Drug Program Information Network (DPIN) database includes all outpatient prescription records, including personal care homes, pharmacare, palliative care, employment/income assistance, and private insurance/out-of-pocket prescription dispensations. MCHP received the DPIN dataset from Manitoba Health as part of the annual data request. Client's identification number, drug cost claimed, drug cost paid, and date of processing were received by the MCHP from Manitoba Health as part of the yearly data request. Both the drug ingredient cost and dispensing cost are included in the total drug cost. Costs are divided into government-paid and non-adjudicated (private/out-of-pocket). The drug costs that the Manitoba government paid were included in the analysis. The data on drugs used from hospital pharmacies, nursing stations, ward stock, and outpatient visits at Cancer Care Manitoba were not included in DPIN. Drug cost claim for an individual was grouped into 12 separate months before death based on the date of claim. Total government-paid drug cost for an individual's last year of life = sum (month1 – month12 cost for drug paid by the government).

Long-term care (personal care home/nursing home) costs

MCHP received long-term care (LTC) assessment and long-term care utilization files from Manitoba Health as part of the yearly data request. These files record the number of days the patient stayed in any long-term care facility in Manitoba during their last year of life, along with the per diem rate. The records of admissions to care facilities with levels of care 1-4 were

included in calculations of long-term care costs. The records of the number of days and per diem rate of patients were used to determine the costs of long-term care of decedents during their last year of life. Long-term cost (LTC) of an individual = Per diem cost*number of days stayed in Long-term care. In some cases, the rate (per diem cost) changed during the time of stay. Any gaps between LTC episodes were excluded to get a better estimation. The total cost of LTC services for an individual was calculated by considering rate changes over LTC episodes.

Monthly long-term care cost on an individual = Long-term cost grouped to 12 separate months prior to the death date based on the separation date. Total last year of life long-term care cost (per individual) = sum (month1 – month12 long-term cost)

Homecare costs

Records of the number of days each decedent received homecare in their last year of life and the total number of open file days for each year were received from homecare assessment, homecare utilization, and homecare-Procura datasets. The total expenditure of the home care program for each year was obtained from Manitoba Health's Annual reports. A per-diem method was used to calculate home care costs following Finlayson et al. 2010.

The per diem cost of home care was calculated using the formula: (total costs of home care program in Manitoba in a specific year ÷ Total number of open file days in that year).

Homecare cost = Per diem cost*number of days received home care.

Homecare costs for an individual were grouped into 12 separate months before death based on the termination date. The total last year of life homecare cost (per individual) = sum (month1 – month12 homecare cost per individual).

Emergency department (ED) costs

The records of emergency department visits by decedents during their last year of life were obtained from the Emergency Department Information System (EDIS), Emergency Care – ADT, and E-Triage. These datasets contain information on emergency visits from 2004 to 2019 exclusively for the Winnipeg Regional Health Authority (WRHA). The EDIS dataset includes emergency department visit data for all of Manitoba starting in December 2020.

Because of the data limitation, this study included emergency department costs for those who received emergency department services in the WRHA hospitals among the decedents who died between 2005 and 2020 in Manitoba. However, from December 2020, the information on emergency department visits was included for all the other regional health authorities in Manitoba.

Due to the absence of the data attached to each record, the average direct cost per visit to the emergency department for each year in Manitoba was used in the analysis. The average direct cost per emergency care visit was received from the CIHI (“Canadian Institute for Health Information. Trends in hospital spending, 2005–2006 to 2021–2022, data tables- Series C”). As direct costs per emergency department visit for 2003-2004 and 2004-2005 were not published at CIHI, the average per-visit costs for 2005-2006 were assigned to the emergency department visit records in 2003-2004 and 2004-2005.

Emergency Department cost of an individual = Average per visit direct cost*number of visits to the Emergency Department. Emergency department costs for an individual were grouped into 12 separate months prior to death based on the discharge date. The total last year of life emergency department cost of an individual = sum (month1 – month12 emergency department cost per individual).

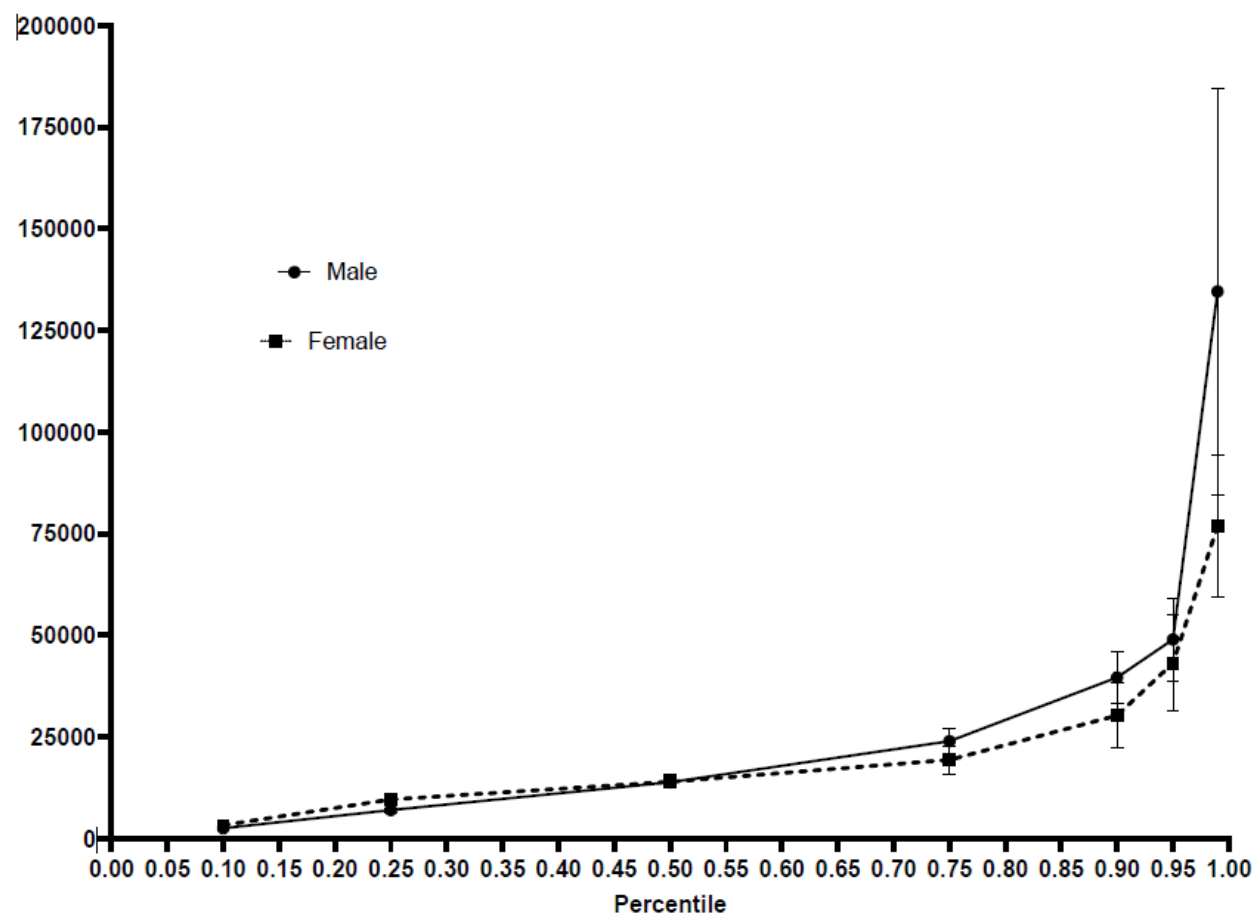
The total costs of an individual in the last year of life were calculated as the total healthcare cost in the last year of life for a decedent = Sum (total last year of life inpatient cost + total last year of life day surgery cost + total last year of life government-paid physician services + total last year of life government-paid drug cost + total last year of life long-term care cost + total last year of life homecare cost + total last year of life emergency department cost).

Note: The monthly costs for each service were converted to 2022 Canadian dollars using the monthly CPI for Health Personal Care in Manitoba and the following formula:

The amount of cost in January 2005 in 2022 dollar

$$= (\text{The amount of cost in January 2005}) \times \frac{\text{CPI in January 2022}}{\text{CPI in January 2005}}$$

Appendix II.3 Mean differences in healthcare expenditure in the last year of life between immigrants and non-immigrants (adjusted) by sex using Quantile regression



Differences in HC costs between immigrants and non-immigrants by sex

Male:	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	99th Percentile
	2504 (2329, 2678)	6981 (6473, 7489)	13832 (12822, 14842)	23940 (20845, 27034)	39593 (33114, 46071)	48940 (38692, 59187)	134552 (84449, 184655)
Female:	10th Percentile	25th Percentile	50th Percentile	75th Percentile	90th Percentile	95th Percentile	99th Percentile
	3276 (2993, 3558)	9580 (9038, 10122)	13979 (12341, 15617)	19374 (15908, 22841)	30277 (22187, 38367)	43126 (31284, 54968)	76827 (59214, 94440)

Adjusted for relationship status, residence, comorbidity index, place of death, neighbourhood income quintiles, causes of death, employment and income assistance, rent assistance, and year of death.

Appendix II.4 Hospitalization in the last year of life by immigration status and LTC use

Immigration Status	LTC Stay	Hospitalized: No N (%)	Hospitalized: Yes N (%)	Total
Immigrants	No LTC	511 (23.01)	1710 (76.99)	2221
	LTC	117 (47.18)	131 (52.82)	248
	Total immigrants	628 (25.5)	1841 (74.5)	2469
Non-immigrants	No LTC	2611 (64.92)	1411 (35.08)	4022
	LTC	516 (71.77)	203 (28.23)	719
	Total non-immigrants	3127 (65.96)	1614 (34.04)	4741

Appendix II.5 Unadjusted and adjusted odds ratios for hospitalization between immigrants and non-immigrants by LTC stay (p-value of interaction between immigration status and LTC stay is <0.0001).

LTC Stay Status	LTC Stay	Unadjusted ORs (95% CI)	Adjusted ORs (95% CI)
No LTC Stay	Immigrants	5.39 (4.82, 6.02)	10.32 (8.91, 11.96)
	Non-immigrants	1 (ref.)	1 (ref.)
LTC stay	Immigrants	2.85 (2.11, 3.83)	3.29 (2.36, 4.58)
	Non-immigrants	1 (ref.)	1 (ref.)

Adjusted for relationship status, residence, comorbidity index, place of death, neighbourhood income quintiles, causes of death, employment and income assistance, rent assistance, and year of death.

Appendix II.6 Percentage of users and average healthcare costs for the healthcare facilities among immigrants by sex

	Males		Females		P-value of chi sq
	%	AC (\$)	%	AC (\$)	
Inpatient hospital care	72.5	33561	76.4	34649	0.0001
ICU users and Inpatient hospital care for them	22.2	76519	16.0	67941	0.0001
Day Surgery care	22.3	522	19.2	376	0.03
Long-term care	7.4	1148	11.9	1888	0.0001
Home care	24.5	1516	30.9	2034	0.0001
Drug	64.4	2398	75.3	2298	0.0001
Emergency Department Care	61.5	279	65.3	311	0.02

CHAPTER 3

TRAJECTORIES OF HEALTHCARE COSTS OF IMMIGRANTS AND NON-IMMIGRANTS IN MANITOBA

ABSTRACT

Background: The healthcare budget in Canada, at both federal and provincial levels, has shown a consistent increase over time. Canada has a large and growing immigrant population. A longitudinal analysis of healthcare use and costs for immigrants and non-immigrants, from arrival onward and in the years before death, may offer insights into how healthcare use and costs change in the years leading up to death.

Objectives: This study examines trends in healthcare utilization and costs among immigrants compared to non-immigrants. It aims to determine whether the healthcare use and costs of immigrants differ from those of non-immigrants over time following their arrival, and whether these differences persist in the final decade before death. Additionally, the research compares these patterns by age between the two groups.

Methodology: The population-based study used 16 databases linked at the individual level, including immigration records, medical claims, hospital abstracts, drug prescriptions, emergency department visits, home care, long-term care, housing and employment/income assistance for immigrants and non-immigrants between 1995 and 2023. To examine differences in healthcare use and costs over time between immigrants and non-immigrants after immigrants' arrival, the study used a forward-looking analysis covering 15 consecutive years and presented in section 1. In addition, to examine differences in healthcare use and costs between immigrants and non-immigrants over the 10 years preceding death, the study employed a backward-looking analysis

of 10 years preceding death, as presented in section 2. The study employed a two-part hurdle model: the first part used a logit model to determine whether an individual incurred any annual healthcare costs, while the second part used generalized estimating equations (GEE) with a log link and gamma distribution to compare overall healthcare cost patterns over time between immigrants and non-immigrants. Additionally, the study used GEE with a binomial distribution and the logit model to estimate odds ratios of healthcare utilization between immigrants and non-immigrants over time.

Results: Forward analysis: The cumulative healthcare costs for immigrants (N=173,423) and non-immigrants (N=749,580) were CA\$14,407 and CA\$18,717, respectively, over the 15-year period from the start of immigrants' healthcare coverage. Immigrants had higher average annual healthcare costs than non-immigrants (Adjusted mean difference [Amd] = CA\$381; CI: 325, 440) in the first five years of coverage. During the initial years, young immigrants had higher costs than their non-immigrant counterparts (Amd: CA\$ 419; CI: 367, 472). Among older adults, immigrants had substantially lower annual healthcare costs than non-immigrants in unadjusted analyses throughout follow-up (Amd: -CA\$ 847; CI: -1088, -565 in the initial 5 years). While the 2SRI model reversed the direction of the association (Amd: CA\$ 351; CI: 210, 503 in the initial 5 years). Young female Immigrants had higher odds of being admitted to an inpatient hospital (adjusted Odds Ratio [aOR] = 1.51; CI: 1.48, 1.54) than non-immigrants during the first 5 years of follow-up.

Backward analyses: Immigrants had significantly higher overall healthcare costs in the last year of life than non-immigrants (Amd: CA\$ 14108; CI: 7332, 21934). Immigrants had higher odds of being admitted to an inpatient hospital (aOR = 2.18; CI: 1.92, 2.47) and visiting the emergency department (aOR = 1.92; CI: 1.79, 2.06) in the year of death than non-

immigrants. In contrast, in most of the years preceding death, immigrants consistently incurred lower annual healthcare costs.

Conclusion: The patterns of healthcare use and costs differ between immigrants and non-immigrants, and these differences vary by age. Overall, immigrants incurred lower cumulative healthcare costs and lower utilization of most healthcare services throughout the follow-up period than non-immigrants. The unobserved factors are stronger among older adult immigrants, and larger differences in cumulative costs were observed between older adult immigrants and non-immigrants, indicating less integration of older adult immigrants into the Canadian health system. At the end-of-life, immigrants are more likely to use emergency department care and be admitted to an inpatient hospital, which elevates the overall healthcare costs of immigrants compared to non-immigrants.

3.1 Introduction

Research on healthcare utilization and cost patterns over time among immigrants and non-immigrants is essential to improving healthcare outcomes for everyone and ensuring timely access to care. Existing studies observed differences in health care use between immigrants and non-immigrants. A study using health survey data in Switzerland revealed that immigrants, particularly culturally diverse immigrants, were less likely to visit a physician and more likely to visit the emergency department than non-immigrants (Tzogiou, Boes and Brunner, 2021). The variation in physician visits between immigrants and non-immigrants is mainly attributed to socio-economic factors such as income and occupation (Tzogiou, Boes and Brunner, 2021).

Conversely, variation in emergency department visits is mainly attributed to unobserved factors such as healthcare preferences, health literacy, and systemic barriers or discrimination (Tzogiou, Boes, and Brunner, 2021). Another Spain-based study using cross-sectional data for 2011 observed that immigrants were less likely to use primary care (4 vs 6.7 visits), specialized care (1.8 vs 2.9 visits), planned hospital admission (2 vs 4.23 per 100 individuals) and unplanned hospital admission (3.5 vs 5.2 per 100 individuals) than non-immigrants (Gimeno-Feliu et al., 2021). A British Columbia-based study compared healthcare utilization in the preceding years before Emergency General Surgery (EGS) among immigrants and non-immigrants who underwent EGS between 2013 and 2021. It observed that immigrants were less likely to access healthcare services in the period before their EGS, such as primary care visits (RR: 0.94, 95% CI: 0.92, 0.96), specialist consults (RR: 0.88, 95% CI: 0.85, 0.91), ED visits (RR: 0.70, 95% CI: 0.68, 0.72), and imaging services (RR: 0.96, 95% CI: 0.92, 0), compared to non-immigrants (Guo et al., 2026).

A USA-based cross-sectional study using the generalized linear model found that authorized immigrants incurred lower annual healthcare costs (\$3795) than USA-born individuals (\$6088) (Wilson et al., 2020). Research using cross-sectional data among Venezuelan immigrants and non-immigrants with HIV found that immigrants (\$859) were less likely to use non-hospital care compared to non-immigrants (\$1,797). In addition, immigrants incurred less expenditure in government-funded healthcare services (25.37%) than non-immigrants (Castillo-Canon et al., 2021).

Though immigrants had better health than the Canadian-born population (Healthy Migrant Effect) shortly after arrival, their health advantage declined rapidly with age compared to non-immigrants, a phenomenon known as unequal weathering (Loi et al., 2025). This decline is mainly due to adopting new lifestyles in the host country, coupled with stress and difficulties in integrating into the new society (McDonald and Kennedy, 2005; Ng et al., 2011; Vang et al., 2015; Cheung et al., 2016; Holz, 2022). Acculturation to the new environment and delay in access to healthcare for immigrants are also critical for the declining health of immigrants over the years since immigration. Immigrants with shorter duration of stay (<10 years) had lower rates of access to and utilization of healthcare than those with longer duration of stay (>10 years), despite universal health coverage in Canada (Leburn, 2012).

An Ontario-based study on the end-of-life healthcare utilization and location of death between recent immigrants and long-term residents revealed that immigrants were more likely to receive intensive and inpatient healthcare and die in an acute care setting compared to long-term residents, resulting in disproportionate demand for intensive care facilities and healthcare costs, thus imposing significant rise in the financial burden on the national and provincial health systems (Yarnell et al., 2017; Shen et al., 2019; Quach et al., 2021; Jo et al., 2023).

The research findings mentioned above raise questions and expose research gaps regarding the trajectories of immigrant healthcare utilization costs among immigrants and non-immigrants. The research gap limits our understanding of patterns in healthcare utilization and costs over time between immigrants and Canadian-born individuals. It raises questions about the association between immigration status and these patterns, as well as the implications of temporal variations in healthcare utilization and costs. As overall and per-person health expenditures in Canada continue to rise, it is essential to examine patterns of healthcare utilization and costs among immigrants and non-immigrants with time before death to ensure on-time healthcare and preventive measures.

First, how do the patterns of healthcare utilization and costs for immigrants and non-immigrants differ over time after immigrants arrive, and in the years preceding death? This issue could assist in determining whether immigrants and non-immigrants have adequate access to healthcare to achieve better health outcomes. Also, data on diagnosed health status, overall healthcare utilization and cost records from administrative datasets, and socioeconomic status over the life-course may provide better information about the patterns of change in healthcare utilization, and healthcare costs among immigrants and non-immigrants.

Immigrants experienced a more rapid decline in health with age compared to non-immigrants (Loi et al., 2025). Additionally, immigrants were more likely to utilize high-intensity care in their final days than the Canadian-born population (Yarnell et al., 2017; Shen et al., 2019; Quach et al., 2021), although they were less likely to use healthcare services after their arrival in Canada (Leburn, 2012; Ravichandiran et al., 2022). In this context, the study used a forward-looking analysis to examine differences in healthcare use and costs over time between immigrants and non-immigrants from the immigrants' initial year of health coverage, along with

a backward-looking analysis among decedents to compare healthcare use and cost patterns in the years before death between immigrants and non-immigrants. This may reveal whether lower healthcare use immediately after immigration and before immigration is associated with more intensive, costly interventions when health issues become severe at the end-of-life. In addition, the finding might help to understand why immigrants' health deteriorates more rapidly with age compared to non-immigrants. Therefore, the results of this study could support actions that help reduce the effects of unequal healthcare access among immigrants by encouraging timely access to healthcare.

Second, whether the differences in healthcare use and cost patterns over time between immigrants and non-immigrants vary by age. Studies on the health of older adult immigrants (age 51 or older) found that older adults had experienced adverse conditions for a longer time in their country of origin (Gubernskaya, 2015) and had worse health than those who immigrated as young adults or as children (Gubernskaya et al., 2013; Nkimbeng et al., 2019). However, Mehta et al. (2016) found that older adult immigrants had lower mortality risk and higher life expectancy than US-born older adults. In general, migrants in Europe had unmet healthcare needs, but the rates were higher among older migrants than among young migrants (Eurostat, 2025).

To examine differences in health care utilization and costs over time between immigrants and non-immigrants by age, this study draws on longitudinal data spanning a long period after immigrants' arrival. This approach yields crucial insights into patterns of healthcare utilization and costs, ultimately aimed at mitigating the risk of comorbidity accumulation and disease severity later in life among the vulnerable groups. The results of this study would help frame

actions to maintain individual health, potentially reducing the excessive demand for intensive care among older adults, especially at the end-of-life.

This exploration is vital for understanding how healthcare use and costs differ over time between immigrants and non-immigrants within younger and older adults. The study results may clarify which immigrant group have experienced more barriers to access healthcare services, especially among older adult immigrants and non-immigrants nearing end-of-life care. The findings could inform policies and strategies to enhance preventive health measures for vulnerable groups, including both immigrants and non-immigrants.

3.2 Objectives

To observe the patterns of healthcare utilization and cost, the study analyzes healthcare use and costs for immigrants and non-immigrants in Manitoba over extended periods. The main objective is to estimate the temporal trends in healthcare costs between immigrants and non-immigrants, with reflections on the pattern of healthcare service utilization over time between immigrants and non-immigrants. Another objective is to investigate whether age at the start of healthcare coverage affects the patterns of healthcare use and costs among immigrants and non-immigrants over time.

Based on the literature, it can be assumed:

Hypothesis 1: The healthcare costs of immigrants are lower than those of non-immigrants upon arrival.

Hypothesis 2: Immigrants have lower healthcare utilization rates upon arrival compared to non-immigrants.

Hypothesis 3: The pattern of annual healthcare costs and utilization rates differs between immigrants and non-immigrants based on age.

Hypothesis 4: Compared to non-immigrants, immigrants have higher average healthcare use and costs in their last year of life, but lower costs in the years before.

3.3 Methods

3.3.1 Data sources

The study uses 15 administrative datasets. IRCC permanent residents' database, the Manitoba health coverage registry, medical claims, Drug Program Information Network (DPIN), hospital abstracts (DAD/MADE), Vital Statistics Mortality, Social Housing-Rented Aid (Manitoba Shelter Benefit), Emergency Department Information System (EDIS), Emergency - Admission, Discharge and Transfer (ADT) and E-Triage, Home Care Assessment, Home Care Utilization, Home Care – PROCURA, Long Term Care Assessment, Long Term Care Utilization, and Social Allowances Management Information Network (SAMIN) datasets linked using scrambled Personal Health Identification Number (PHIN). The study also classifies all individuals into five neighbourhood income quintiles based on the average household income of the place of residence from the 1996, 2001, 2006, 2011, 2016, and 2021 Canadian Censuses, respectively, at the calendar year.

3.3.2 Study design

This population study designed the analysis to estimate patterns of healthcare use and costs among immigrants and non-immigrants, using both forward and backward temporal analyses. The aim of the forward design is to identify patterns of healthcare utilization and costs among immigrants and non-immigrants during the first 15 consecutive years of immigrants' health coverage. Conversely, the backward design aims to analyze healthcare use and costs among immigrant and non-immigrant decedents from the year of death and the nine preceding years. This strategy seeks to clarify differences in healthcare utilization and costs between

immigrants and non-immigrants from the start of immigrants' health coverage, over time, and in the year of death and the years leading up to it.

3.3.2.1 Forward analyses

3.3.2.1.1 Cohort Criteria

The cohort consisted of all immigrants and non-immigrants aged 20 to 60 at the commencement of the follow-up period and was monitored for a minimum of 3 years or a maximum of 15 years. Immigrants who began their healthcare coverage in Manitoba between January 1995 and March 2021 were followed for up to 15 years, or until they lost their coverage due to death or relocation outside the province, whichever occurred first. Non-immigrants were tracked starting from January 1995 if they had healthcare coverage as of that date, or from their respective healthcare coverage start dates between January 1995 and March 2021. Follow-up for non-immigrants continued for up to 15 years, or until loss of healthcare coverage due to death or moving out of the province during the study period, whichever occurred first. Individuals with less than 3 years of follow-up were excluded from the cohort.

3.3.2.1.2 Variable definitions

Outcome variable

The annual total direct healthcare cost per individual is the outcome variable in this study. The annual cost is converted to the 2023 Canadian dollar using the Consumer Price Index (CPI). The total direct cost of this study is the sum of physician, inpatient hospital, day-surgery, emergency department, long-term care, home care, and drug-related costs. The records of healthcare use and costs were received from the administrative dataset annually, based on calendar year. Therefore, the records for the year in which follow-up starts or ends could be part of that year. This was annualized by multiplying the short-period costs by the annualization

factor. The formula used for this factor is $(N/365) \times \text{CA\$}$, where N represents the number of days within the relevant year during which an individual's Manitoba health insurance coverage was active, and CA\$ denotes the Canadian dollar amount spent on healthcare during that period. The study restricts the factor to a maximum value of 12.

Comparison groups

This study's comparison groups are immigrants who started coverage between 1 January 1995 and March 2021, and Non-Immigrants who were born in Canada or who resided in Manitoba before the creation of the registry in 1970 and had Manitoba healthcare coverage in 1995, or whose coverage started between 1995 and 2021.

Socio-demographic and other variables

Socio-demographic and economic characteristics for the annual healthcare cost pattern analyses include age, sex, marital status, rural or urban residence, receipt of rental assistance, and receipt of employment and income assistance. The immigrant characteristics are immigrant status (yes/no), refugee status (yes/no), economic immigrant status (yes/no), and region of birth. The Charlson Comorbidity Index was used to control health status. The 17 diagnostic categories and their associated weights were used to define the Charlson comorbidity index. At the time of the last follow-up within the population, all individuals were classified as either 1) alive, 2) dead, or 3) outmigrant.

Time periods

The time periods were divided into three 5-year periods from the start to the end of follow-up for simplicity. The periods are 1) coverage initial period (0 – 4 years); 2) mid follow-up period (5 – 9 years); and 3) late follow-up period (10 – 14 years).

3.3.2.2 Backward analysis

3.3.2.2.1 Cohort Criteria

This cohort study assessed annual healthcare utilization and cost patterns among immigrants and non-immigrants who died between January 1997 and March 2023, provided they had at least 3 years of healthcare coverage records in Manitoba at the time of their death.

Participants included individuals aged 20 or older at the time of the first follow-up. The follow-up period extended from the year of death back to 10 years prior or until the date of cancellation of healthcare coverage, depending on which occurred first. Consequently, the maximum follow-up duration for this cohort was 10 years, while the minimum was set at 3 years.

3.3.2.2.2 Variable definitions

This backward analysis among decedents utilizes the same outcome variable, comparison groups, and socioeconomic factors, along with other variables outlined in forward analysis. For the outcome variable, the same annualization factor procedure described in forward analysis was applied to records of those whose follow-up started or ended in a year that was not a full year.

Time trend

The time variable ranged continuously from 0 to -9, allowing for a maximum follow-up of 10 years. Here, time = 0 indicates the year of death, while time = -1 represents the year before death and continues backward.

3.3.3 Data analysis

3.3.3.1 Forward analysis

Generalized Linear Models (GLMs) offer alternative distributions and transformations to address the right-skewness of healthcare costs (Mihaylova et al., 2011). A GLM with a gamma distribution and a log link is more robust for analyzing right-skewed healthcare costs (Malehi et

al., 2015). In longitudinal data, annual healthcare costs for the same subject may be correlated across time (Liu et al., 2008). Generalized Estimating Equations (GEE) is an extension of the GLM proposed by Liang and Zeger (1986) that provides a consistent estimate of the regression parameter for repeated-measured annual healthcare costs, even when the correlation structure is mis-specified (Kwon, 2017; Liang & Zeger, 1986). Another advantage of the GEE model is its ability to account for correlations in longitudinal responses by selecting a variance structure. When the correlation between a subject's annual healthcare costs declines over time, an autoregressive covariance structure is appropriate (Grady & Helms, 1995).

Existing studies have used the GEE model with a log link and gamma distribution, along with a first-order autoregressive correlation matrix, to estimate the cost using longitudinal data (Rivera-Hernandez et al., 2022; Nabi et al., 2024). The existing study used a two-part hurdle model, with the first part employing a logit model to determine the presence of annual costs and the second part utilizing a GEE model with a log link, gamma distribution, and a first-order autoregressive correlation matrix to include all observations in the analysis (Buntin & Zaslavsky, 2004; Jennum et al., 2021). The study also used the GEE model with the log link and gamma distribution to estimate average costs, and the GEE model with logit regression to estimate odds ratios of healthcare use between immigrants and non-immigrants for each healthcare service.

The specification of my estimated regressions is based on the following:

$$\begin{aligned} \text{Healthcare costs}_{it} = & \alpha_0 + \beta_1 \text{Immigrants}_i + \sum_k \beta_{2k} \text{Time trend}_k + \\ & \sum_k \beta_{3k} (\text{Immigrants} \times \text{Time trend}_k) + \sum_M \beta_{4M} \text{Age at start of followup}_{Mi} + \beta_5 \text{Sex}_i + \\ & \beta_6 \text{Marital status}_{it} + \beta_7 \text{Urban/Rural}_{it} + \beta_8 \text{EIA}_{it} + \beta_9 \text{Rent assistance}_{it} + \\ & \sum_N \beta_{10} \text{Charlson comorbidity index}_{it} + \beta_{11} \text{Status at last followup}_i + \varepsilon_t \end{aligned}$$

The expected population average function for a log link gamma distribution on the log scale is as follows:

$$\begin{aligned}
& \text{Log}(E[\text{Healthcare costs}_{it}]) \\
&= \alpha_0 + \beta_1 \text{Immigrants}_i + \sum_k \beta_{2k} \text{Time trend}_k \\
&+ \sum_k \beta_{3k} (\text{Immigrants} \times \text{Time trend}_k) \\
&+ \sum_M \beta_{4M} \text{Age at start of followup}_{Mi} + \beta_5 \text{Sex}_i + \beta_6 \text{Marital status}_{it} \\
&+ \beta_7 \text{Urban/Rural}_{it} + \beta_8 \text{EIA}_{it} + \beta_9 \text{Rent assistance}_{it} \\
&+ \sum_N \beta_{10} \text{Charlson comorbidity index}_{it} + \varepsilon_t
\end{aligned}$$

3.3.3.1.1 Endogeneity to omitted and selection bias

While economic and family-class immigrants were subject to medical screening at the time of immigration, refugees and certain family-class immigrants were exempt from this requirement (Lu and Ng, 2019). Furthermore, the medical examination for those seeking permanent residence primarily assessed their potential impact on public health services and could result in inadmissibility due to excessive demand on these services (Lu and Ng, 2019). In addition, several infections might remain latent for many years and be detected in immigrants later (Barnett et al., 2023). Trauma-related mental health conditions might also be overlooked by the healthcare systems of the immigrant country of origin (Rosenthal, 2018).

Moreover, conditions and circumstances surrounding migration, as well as epidemiological patterns of infectious diseases in the country of origin, might increase the risk of infectious diseases among immigrants in the host country (Barnett et al., 2023; Castelli and Sulis,

2017; Greenaway and Castelli, 2019; Schlagenhauf et al., 2018). The pre-immigration disease burden of immigrants remained unobserved and may be related to observed comorbidities, thereby contributing to omitted-variable bias.

Economic immigrants in Canada are positively selected under the nation's immigration policy, which assesses individuals on human capital, age, and medical screening (Lu and Ng, 2019). In contrast, refugees are exempt from inadmissibility based on healthcare demand and health condition (Lu and Ng, 2019). They also face unique health challenges strongly shaped by the traumas and circumstances they experienced in their home countries (Muller et al., 2018). As a result, the healthy migrant effect (HME) was more pronounced among economic immigrants and significantly weaker among refugees, reflecting differences in selection criteria (Lu and Ng, 2019). Therefore, the selection process for immigrants might affect their observed comorbidities in the host country, potentially introducing selection bias.

As a result, the estimates might be biased due to endogeneity arising from the lack of pre-immigration information. Therefore, I used the two-stage residual inclusion model suggested by Terza et al. (2008), especially for non-linear regression analysis in health research, to address endogeneity. In the first stage, I estimated a negative binomial model with the outcome being the sum of the weighted Charlson Comorbidity Index scores for each year. The instruments were region of birth, economic immigrant (yes/no), and refugee (yes/no).

Instruments

Using instruments helped estimate the causal effect of an endogenous variable, specifically comorbidity, which correlates with unobserved variables and factors that contributed to selection bias, and the disease burden before immigration. This method helped isolate the effect of comorbidity on the outcomes of interest, thereby improving the validity of the findings

in the presence of potential confounding factors. The research employed the following instrumental variables to address endogeneity in comorbidity.

Region of origin

The lack of financial support for healthcare costs in low- and middle-income countries is a substantial barrier to the use of healthcare services (Mills, 2014). Furthermore, the social, legal, economic, and cultural contexts of a country or region, as well as the characteristics shared by a community, significantly influence health outcomes (Zimmerman & Pronk, 2025; McKinlay, 1975).

Economic immigrants

Economic immigrants generally arrive in better health and with lower comorbidity, as they are selected based on human capital criteria and undergo medical screening during the immigration process (Lu & Ng, 2019).

Refugee status

Forced displacement, disruptions in healthcare, and socio-economic and political marginalization experienced prior to migration, along with integration challenges after migration, may lead to poor health outcomes (Kumar et al., 2019; Kumar and Krasnik, 2020; Wanigaratne et al., 2018; Lange et al., 2024). Additionally, Canadian immigration policy allows refugees to be exempt from health-based admissibility rules for humanitarian reasons, which might lead to poorer health among refugees compared to non-refugee immigrants (Wanigaratne et al., 2015).

Exogeneity of instruments

Economic immigrant and refugee status are determined legally by immigration authorities based on the specific immigration programs under which individuals are selected. In

contrast, a person's region of origin is established at birth. As fixed attributes, economic immigrant and refugee status are time-invariant and do not influence eligibility for getting healthcare services in the universal system, healthcare provider behaviour, or rules regarding treatment intensity. Consequently, these statuses might not directly affect healthcare utilization or costs.

Instead, these instrumental variables affect healthcare utilization and costs indirectly by influencing comorbidity burden and health needs. The exception is for refugee claimants, who were covered by a federal program while waiting for their PR. I could not separate them from the refugee group, although many refugees were not refugee claimants. In the second stage, the research used a hurdle model to analyze annual healthcare costs. First, I applied pooled logistic regression to estimate the probability of incurring any costs in a given year ($\text{cost} > 0$). Next, I examined a gamma distribution and a log link, using Generalized Estimating Equations (GEE) with first-order autocorrelation to account for within-individual temporal correlation. In the GEE gamma model, where the outcome is annual healthcare costs, predictors included immigrant status (yes/no), age, time periods, the interaction between immigrant status and time periods, Charlson comorbidity index, EIA, rent assistance, marital status, status at end of follow-up, and the residuals from the first stage. If the residual term is significant, it indicates endogeneity and warrants its inclusion in the model. The study reports the results of 2SRI if the residual variable in the second stage is significant. Additionally, I estimated the odds ratio for healthcare utilization using GEE with a logit regression, controlling for 2SRI, to assess variation in healthcare utilization over time between immigrants and non-immigrants.

3.3.3.1.2 Inverse probability of censoring weights

The study tracked individuals from the beginning of healthcare coverage through 15 consecutive years. But in the dataset, follow-up for some individuals was lost before the last year of the study due to death or outmigration. Since losses to follow-up can provide informative insights (Howe et al., 2016), the estimates derived from this data may be biased. To mitigate selection bias arising from these losses, the study employed inverse probability of censoring weights in its estimates to achieve unbiased results (Seamon and Copas, 2009; Robin et al., 1995; Hernán et al., 2004; Hernán & Robins, 2016).

Information on the individual, including immigrant status (yes/no), age, comorbidities, neighbourhood income quantile, employment and income assistance, rent assistance, marital status, along with a log of the previous year's healthcare costs and time trend, was used to estimate inverse probability of censoring weights. The outcome of the pooled logistic regression was uncensored: 1 if the individual was followed to the end of the study, and 0 if lost to follow-up due to cancellation of healthcare insurance coverage for death or outmigration. Age was included in the regression as both a linear and a quadratic term.

3.3.3.2 Backward analyses

3.3.3.2.1 Data analysis

In this decedent's cohort, the same statistical analysis was used except for the inverse probability censoring weight. Here, I did not use censoring weight as this is a backward analysis. Logistic regression for whether healthcare services were used in the first part, and GEE with a gamma distribution and log link for cost in the second part of the hurdle model were used. In addition, a GEE model with logit regression was used to estimate odds ratios for healthcare use between immigrants and non-immigrants for each service. The same procedure and the same

adjusted variables of forward analysis were used for the 2SRI model. Table 3.7 presents demographic characteristics and annual healthcare costs for immigrants (coverage start 1995–2021) and all non-immigrants who resided in Manitoba during the same period. The total population size is 222,786. Among them, 4,159 were immigrants, and 218,627 were non-immigrants. Ninety-four percent of individuals were 50 years of age or older at the start of follow-up, and among immigrants, this proportion was about 82 percent.

3.4 Results

3.4.1 Forward analysis

Table 3.1 presents demographic characteristics and annual healthcare costs for immigrants (coverage start 1995–2021) and all non-immigrants who resided in Manitoba during 1995–2021. The total population size is 749,580. Among them, 173,423 were immigrants, and 576,157 were non-immigrants. Sixty-three percent of individuals were between 20 and 40 years of age at the start of follow-up, and among immigrants, this proportion was about 75 percent. The average annual healthcare cost per individual increased gradually over the follow-up period, from C\$693 in the first year to C\$2,673 in the fifteenth year, and was consistently higher among non-immigrants than among immigrants, except in the second and third years of follow-up.

Among the study population, sex distribution was roughly equal. Females had higher average annual healthcare costs (C\$1,609) than males (C\$1,276). Among the study population, 27% were married or had a common-law partner. Over a 15-year follow-up, married individuals had lower average annual healthcare costs (C\$1,321) than unmarried individuals (C\$1,598).

Table 3.1: Socio-demographic characteristics and average annual healthcare costs (AC) during 1995–2023

Characteristics	All			Immigrants			Non-Immigrants		
	N	%	AC (C\$)	N	%	AC (C\$)	N	%	AC (C\$)
All*	749580	100	1444	173423	23.1	1015	576157	76.9	1536
Age at start of follow-up									
21 – 30	234773	31.3	920	64514	37.2	930	170259	29.6	917
31 – 40	240189	32.0	1031	66416	38.3	938	173773	30.2	1056
41 – 50	161052	21.5	1594	32804	18.9	1039	128248	22.3	1696
51 – 60	113566	15.2	2955	9689	5.6	1939	103877	18.0	3024
Time Trend*									
1 st year	749580	100	693	173423	23.1	624	576157	76.9	713
2 nd year	749580	100	666	173423	23.1	813	576157	76.9	622
3 rd year	749580	100	879	173423	23.1	949	576157	76.9	858
4 th year	700706	100	1013	153786	22.0	952	546920	78.0	1031
5 th year	661909	100	1094	137667	20.8	953	524242	79.2	1131
6 th year	630537	100	1228	123722	19.6	984	506815	80.4	1288
7 th year	602322	100	1320	110546	18.4	1024	491776	81.7	1387
8 th year	578487	100	1368	99531	17.2	1051	478956	82.8	1434
9 th year	556649	100	1470	88496	15.9	1140	468153	84.1	1532
10 th year	537817	100	1709	79548	14.8	1140	458369	85.2	1808
11 th year	519433	100	2006	70427	13.6	1268	449006	86.4	2122
12 th year	502002	100	2134	61598	12.3	1324	440404	87.7	2247
13 th year	485612	100	2430	53546	11.0	1530	432066	88.9	2542
14 th year	471645	100	2535	47187	10.0	1513	424458	90.0	2649
15 th year	459594	100	2673	42309	9.2	1542	417285	90.8	2787
Sex									
Male	376319	48.4	1276	289370	50.2	751	86949	50.2	1388
Female	373261	51.6	1609	286787	49.8	1272	86474	49.8	1683
Having Married/ Common-Law Partner at the end of follow-up									
Yes	362461	26.9	1321	111740	64.4	934	250721	43.5	1702
No	387119	73.1	1598	61683	35.6	1056	325436	56.5	1392
Residence at the end of follow-up									
Rural Residence	247556	33.0	1427	24497	14.1	1013	223059	38.7	1455
Urban Residence	500544	66.8	1485	148585	85.7	1062	351959	61.1	1604
Unknown	1480	0.2	673	341	0.2	632	1139	0.2	742

Characteristics	All			Immigrants			Non-Immigrants		
	N	%	AC (C\$)	N	%	AC (C\$)	N	%	AC (C\$)
Comorbidity Index at the end of the year of follow-up									
0	524080	69.9	741	144156	83.1	684	379924	65.9	755
1 - 2	157549	21.0	2869	25493	14.7	2117	132056	22.9	2991
3 - 4	31662	4.2	14674	2189	1.3	10865	29473	5.1	15054
4+	36289	4.9	45954	1585	0.9	32675	34704	6.0	47626
Employment/ Income Assistance at the end of the year of follow-up									
Yes	24347	3.2	4808	20099	3.5	3523	4248	2.5	4977
No	725233	96.8	1292	556058	96.5	942	169175	97.6	1369
Rent Assistance at the end of the year of follow-up									
Yes	1257	0.2	2875	401	0.2	1394	856	0.2	1002
No	748323	99.8	1428	173022	99.8	1002	575301	99.8	1518
Immigration Characteristics									
Refugee									
Yes				19619	11.3	1407			
No				153804	88.7	963			
Admission Category									
Economic Immigrant				116415	67.1	892			
Family Class				36666	21.2	1153			
Refugee				19619	11.3	1407			
Other Immigrant				723	0.4	1682			
Region of Origin									
Southeast Asia				49084	28.3	954			
South Asia				34309	19.8	1064			
Rest of Asia				29071	16.8	804			
East Europe				12536	7.2	966			
Rest of Europe				10087	5.8	891			
North and East Africa				12935	7.5	1409			
Sub-Saharan Africa				9514	5.5	1444			
North America and Oceania				3791	2.2	1329			

Characteristics	All			Immigrants			Non-Immigrants		
	N	%	AC (C\$)	N	%	AC (C\$)	N	%	AC (C\$)
Latin America and Caribbean				12074	7.0	1048			
Unknown Region of Birth				22	0.01	799			

* The first two rows and time trends rows represent row% and the remainder column %

Urban residents (67% of the population) had higher annual healthcare costs than rural residents (C\$1,485 vs C\$1,427), and a greater proportion of immigrants (86%) lived in urban areas compared with non-immigrants. During the follow-up period, individuals with more comorbidities had higher average annual costs (C\$741 for those without comorbidities vs C\$45,954 for 4 or more comorbidities).

Among Manitoba residents, individuals who received employment and income assistance (C\$4,808 vs C\$1,292) or rent assistance (C\$2,875 vs C\$1,428) had higher average annual healthcare costs than those who did not receive. Among immigrants, refugees (\$1,407) had higher annual healthcare costs than non-refugees (\$963), and those who immigrated from Africa (\$1,409 for North and East Africa; \$1,444 for Sub-Saharan Africa) also had higher annual costs than those who immigrated from other regions.

Table 3.2 presents the trend of healthcare usage among immigrants and non-immigrants during the follow-up period. In the first 5 years of follow-up, a lower proportion of immigrants (71.1% vs 78.1%) visited a physician, were admitted to a hospital (7.5% vs 9.8%), or had a day-surgery (5.5% vs 9.9%), and received government-funded drugs (5.5% vs 9.9%).

Table 3.2: Trends in Healthcare Service Use: Immigrants vs. Non-Immigrants

	Coverage initial period (0 - 4 years)			Mid follow-up period (5 –9 years)			Late follow-up period (10 –14 years)		
Follow-up time groups	IM (%)	NIM (%)	Dif. (p.v)	IM (%)	NIM (%)	Dif. (p.v)	IM (%)	NIM (%)	Dif. (p.v)
Physician care									
All	71.18	78.07	-6.9 <.0001	77.88	81.76	-3.9 <.0001	80.94	84.76	-3.8 <.0001
Baseline age 20 - 40	70.90	75.51	-4.6 <.0001	77.29	77.98	-0.7 <.0001	79.86	80.52	-0.7 <.0001
Baseline age 41 - 60	72.03	81.80	-9.8 <.0001	79.50	86.84	-7.3 <.0001	79.50	86.84	-7.3 <.0001
Hospital Care									
All	7.56	9.81	-2.3 <.0001	8.21	12.54	-4.3 <.0001	7.83	13.21	-5.4 <.0001
Baseline age 20 - 40	8.38	9.44	-1.1 <.0001	8.50	10.93	-2.4 <.0001	7.14	10.25	-3.1 <.0001
Baseline age 41 - 60	5.08	10.36	-5.3 <.0001	7.39	14.72	-7.3 <.0001	9.67	17.14	-7.5 <.0001
Long-Term Care									
All	5.11	6.20	-1.1 <.0001	4.47	6.31	-1.8 <.0001	3.38	6.26	-2.9 <.0001
Baseline age 20 - 40	6.06	6.43	-0.4 <.0001	5.08	5.78	-0.7 <.0001	3.23	4.81	-1.6 <.0001
Baseline age 41 - 60	2.23	5.85	-3.6 <.0001	2.79	7.02	-4.2 <.0001	3.78	8.18	-4.4 <.0001
Emergency Department Care									
All	2.80	0.56	2.2 <.0001	3.48	1.29	2.2 <.0001	3.61	1.45	2.2 <.0001
Baseline age 20 - 40	2.94	0.70	2.2 <.0001	3.59	1.31	2.3 <.0001	3.62	1.35	2.3 <.0001
Baseline age 41 - 60	2.37	0.36	2.0 <.0001	3.17	1.26	1.9 <.0001	3.58	1.58	2.0 <.0001
Government Funded Drug									
All	5.52	9.91	-4.4 <.0001	5.95	11.98	-6.0 <.0001	7.64	15.02	-7.4 <.0001
Baseline age 20 - 40	4.12	6.69	-2.6 <.0001	4.07	7.43	-3.4 <.0001	4.88	8.59	-3.7 <.0001
Baseline age 41 - 60	9.78	14.61	-4.8 <.0001	11.15	18.10	-7.0 <.0001	14.92	23.56	-8.6 <.0001

IM= Immigrants ; NIM=Not-Immigrants ; Dif. = Difference in % of users; p.v = P-value of χ^2 test

The differences in visiting a physician (-9.8 vs -4.6), using hospital care (-5.3 vs -1.1), and receiving government-funded drugs (-4.8 vs -2.6) during the first five years between immigrants and non-immigrants were greater among those whose age at the first follow-up was between 41 and 60 years than those aged 20 to 40 years.

The differences in healthcare users between immigrants and non-immigrants decreased faster over time among the younger group (age at the first follow-up was between 20 and 40), whereas, except for visiting a physician or emergency department, the differences in healthcare users between immigrants and non-immigrants increased over time among the older adult group (age at the first follow-up was between 41 and 60).

Appendix III.1 outlines the patterns of average annual healthcare costs by service and baseline age group over time for both immigrants and non-immigrants. During the first five years, immigrants incurred higher average annual expenses for physician care (C\$416 compared to C\$345) and emergency department visits (C\$11 versus C\$2) than their non-immigrant counterparts. In contrast, they had lower costs for inpatient care (C\$311 compared to C\$328), day surgery (C\$45 compared to C\$53), and government-funded medications (C\$69 versus C\$93). Notably, the variation in annual average healthcare service costs between immigrants and non-immigrants was evident across different baseline age groups. The data indicate that among individuals whose follow-up began between the ages of 20 and 40, immigrants incurred higher expenses for physician care (C\$416 compared to C\$299), inpatient hospital services (C\$327 versus C\$256), and emergency care (C\$12 compared to C\$2.8) than non-immigrants. However, over time, average annual healthcare costs, except for emergency department visits, tended to be higher for non-immigrants than for immigrants.

Table 3.3 and Figure 3.1 illustrate the cumulative average annual healthcare costs for immigrants and non-immigrants over a span of 15 years. Both groups experienced a progressive increase in costs over time. While cumulative costs for immigrants were marginally higher than those for non-immigrants in the first 5 years (C\$4,194 compared to C\$4,176), the overall trend showed that immigrants incurred lower cumulative healthcare costs than non-immigrants, with this gap widening over time. By year 15, the cumulative costs stood at C\$14,407 for immigrants and C\$18,717 for non-immigrants.

Table 3.3 and Figures 3.2 and 3.3 present the trajectories of cumulative average costs by baseline age groups. When analyzed by baseline age groups, the cumulative average healthcare cost trajectories exhibited notable differences between immigrants and non-immigrants.

Among younger adults (ages 20–40 at baseline), healthcare costs for immigrants (C\$635 vs C\$622) and non-immigrants in the first year were similar. However, this disparity diminished and ultimately reversed by the end of the follow-up period (C\$12,938 vs C\$14,023). In contrast, among older adults (ages 41–60 at baseline), immigrants consistently incurred lower healthcare costs than non-immigrants, with the gap widening over time (C\$18,332 vs C\$24,993 at the final follow-up).

Table 3.4 shows trends in unadjusted and adjusted mean differences in annual healthcare costs between immigrants and non-immigrants over the follow-up periods. It indicates that unadjusted mean annual healthcare costs gradually increased for both groups during follow-up. Among immigrants, costs rose from C\$905 at the initial follow-up to C\$1,427 at the later follow-ups. For non-immigrants, costs increased from C\$1,132 to C\$2,883.

Table 3.3: Trends in cumulative average annual healthcare service costs with 95% CI over 15 years of follow-up: Immigrants vs. Non-Immigrants

Follow-up years	All		Baseline age 20 - 40		Baseline age 41 - 60	
	IM	NIM	IM	NIM	IM	NIM
1	624 (609, 640)	713 (703, 724)	635 (618, 652)	622 (611, 633)	592 (556, 627)	849 (827, 870)
2	1437 (1413, 1461)	1335 (1247, 1423)	1473 (1448, 1498)	1129 (1114, 1143)	1328 (1266, 1389)	1641 (1424, 1858)
3	2387 (2322, 2452)	2194 (2022, 2365)	2409 (2338, 2480)	1781 (1760, 1802)	2317 (2168, 2467)	2805 (2381, 3229)
4	3277 (3228, 3327)	3164 (2897, 3430)	3323 (3269, 3378)	2511 (2483, 2539)	3139 (3027, 3251)	4099 (3451, 4746)
5	4194 (4133, 4254)	4176 (3810, 4542)	4226 (4162, 4290)	3288 (3250, 3325)	4099 (3953, 4246)	5417 (4542, 6293)
6	5129 (5056, 5201)	5322 (4855, 5790)	5134 (5058, 5210)	4088 (4044, 4132)	5114 (4938, 5290)	7016 (5909, 8123)
7	6043 (5955, 6131)	6458 (5889, 7028)	6012 (5918, 6105)	4917 (4866, 4968)	6131 (5919, 6343)	8542 (7204, 9880)
8	6968 (6869, 7066)	7619 (7008, 8230)	6869 (6763, 6974)	5803 (5736, 5870)	7241 (7012, 7469)	10050 (8624, 11477)
9	8022 (7892, 8152)	8829 (8200, 9458)	7789 (7661, 7917)	6696 (6626, 6766)	8650 (8315, 8985)	11669 (10206, 13131)
10	8975 (8832, 9118)	10249 (9607, 10891)	8654 (8506, 8802)	7734 (7644, 7824)	9831 (9485, 10176)	13586 (12097, 15076)
11	10076 (9871, 10281)	11934 (11271, 12596)	9654 (9415, 9893)	8848 (8753, 8944)	11178 (10778, 11577)	16021 (14487, 17556)
12	11098 (10889, 11307)	13557 (12881, 14234)	10433 (10218, 10647)	10024 (9911, 10136)	12850 (12343, 13357)	18239 (16674, 19804)
13	12298 (12013, 12583)	15414 (14721, 16106)	11336 (11068, 11605)	11274 (11143, 11406)	14827 (14071, 15581)	20903 (19303, 22503)
14	13351 (13046, 13656)	16863 (16692, 17035)	12246 (11939, 12553)	12710 (12513, 12907)	16295 (15535, 17055)	22391 (22091, 22692)
15	14407 (14086, 14728)	18717 (18545, 18888)	12938 (12632, 13243)	14023 (13834, 14212)	18332 (17485, 19181)	24993 (24685, 25301)

Figure 3.1: Trend of cumulative average healthcare costs over the 15 years among immigrants and non-immigrants

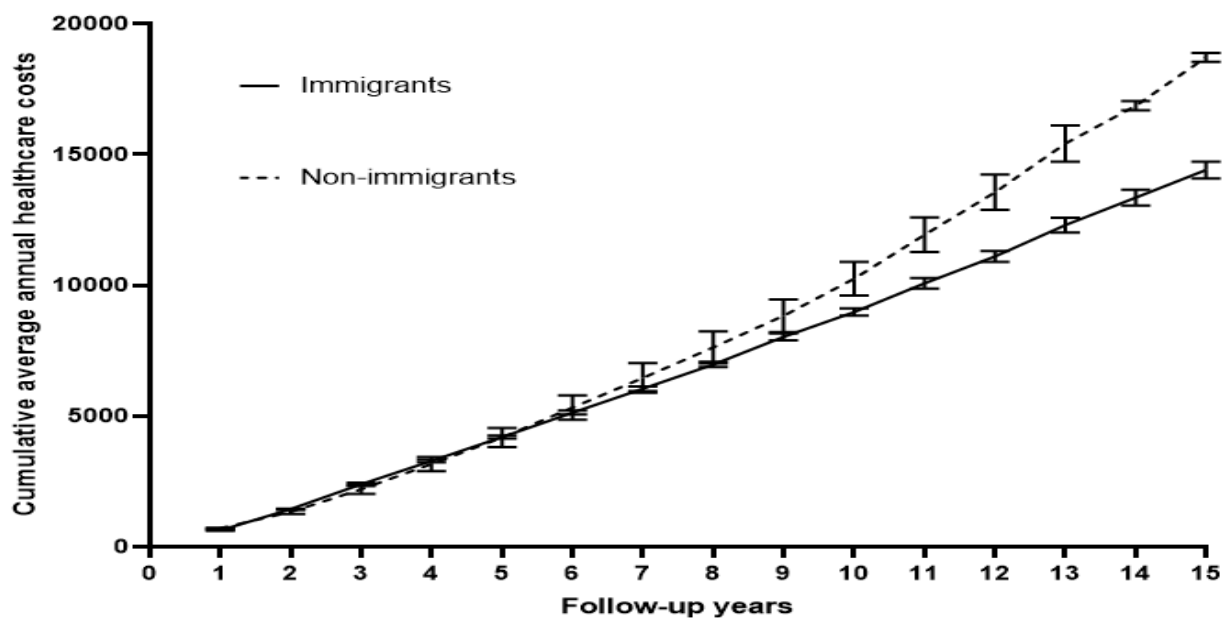


Figure 3.2: Trend of cumulative average healthcare costs over 15 years among immigrants and non-immigrants who were aged 20 to 40 at baseline.

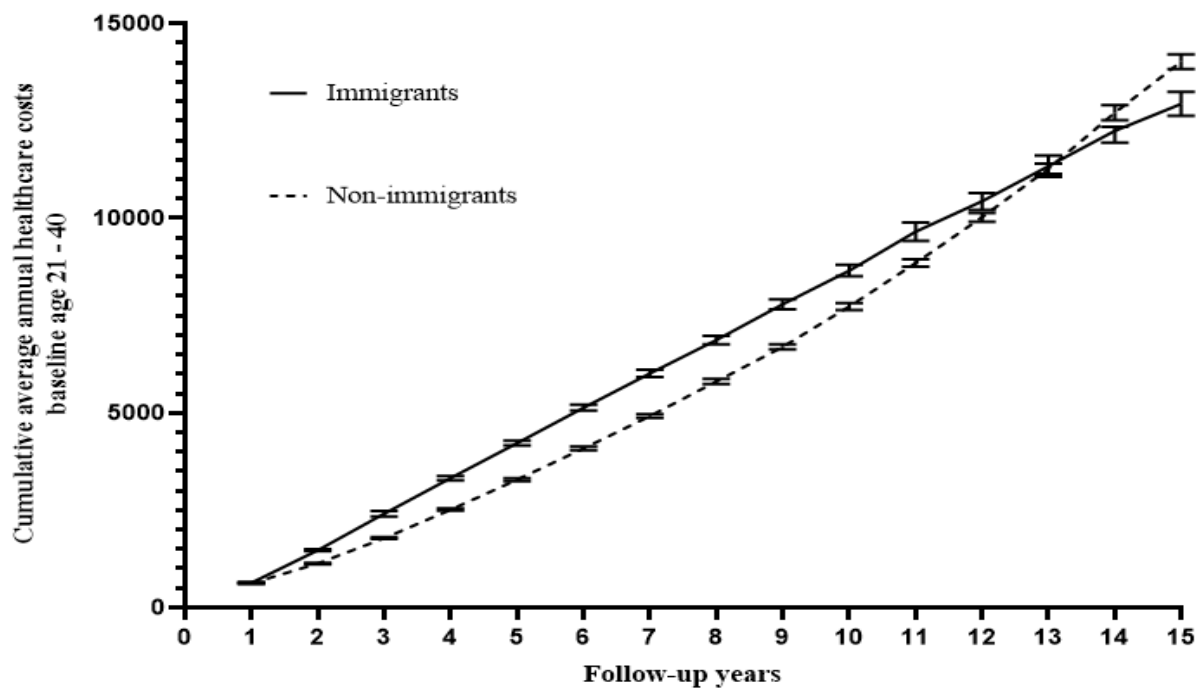
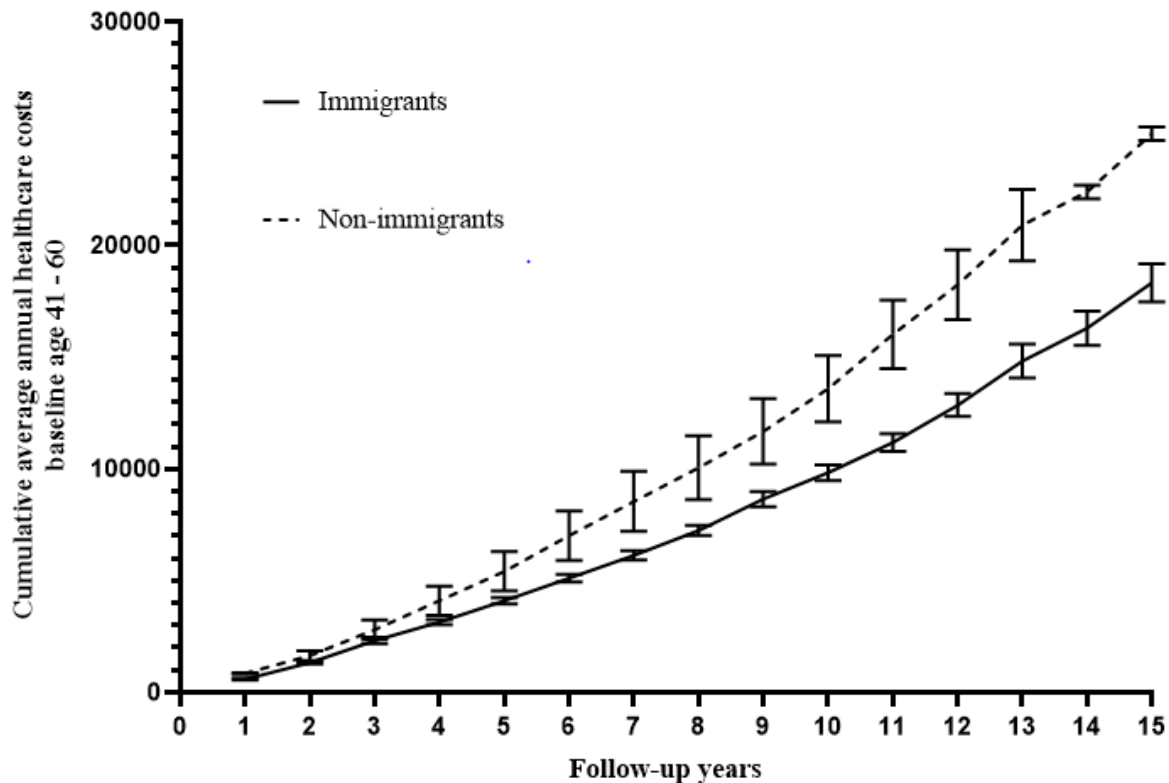


Figure 3.3: Trend of cumulative average healthcare costs over 15 years among immigrants and non-immigrants who were aged 41 to 60 at baseline.



The adjusted mean difference in Table 3.4 reveals higher annual healthcare costs for immigrants (AMd: C\$381; 95% CI: C\$325; C\$440) in the initial period. However, this difference decreased over time, and during the last five years of follow-up, immigrants had lower adjusted annual healthcare costs (AMd: -C\$161; 95% CI: -C\$257; -C\$60) compared to non-immigrants.

Adjusting for age shows that immigrants face higher adjusted costs during their first five years in the country compared to non-immigrants. This suggests that age was a key confounder in reversing the initial cost differences and in narrowing the gap over time.

Additionally, the higher costs for immigrants in the first 10 years post-immigration remained significant after accounting for unobserved factors associated with their comorbidities.

Table 3.4: Trajectories of average annual healthcare costs, including unadjusted and adjusted mean differences between immigrants and non-immigrants.

Follow-up time groups	Immigrants Unadjusted mean Costs (UMC) (CA\$)	Non-immigrants Unadjusted mean Costs (UMC) (CA\$)	Unadjusted* mean differences (UMd, 95% CI)	Adjusted** mean differences (UMd, 95% CI)	Adjusted*** mean differences (UMd, 95% CI)
Coverage initial period (0 - 4 years)	905	1132	-228 (-271, -181)	193 (155, 232)	381 (325, 440)
Mid follow-up period (5 – 9 years)	1060	1772	-713 (-754, -670)	-83 (130, -34)	123 (56, 191)
Late follow-up period (10 – 14 years)	1427	2883	-1456 (-1566, -1336)	-400 (-473, -324)	-161 (-257, -60)

*The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

** Adjusted for age at start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

*** Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at the start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, urban/rural residence, and residuals of the first regression. The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW. Models were analyzed using the Generalized Estimating Equations (GEE) model with a log-gamma distribution for the hurdle model.

Analysis of overall healthcare costs stratified by baseline age groups in Appendix III.2 showed significant confounding across age groups (the p-value for the interaction between age groups and immigrant status in the observed adjusted model is <.0001). Among individuals aged 21–40 years, immigrants had higher annual healthcare costs than non-immigrants during the initial follow-up period (0–4 years), with an unadjusted mean difference of C\$199 (95% CI: C\$156, C\$243). Adjusting for observed covariates increased the estimated difference to C\$349 (95% CI: C\$321, C\$377), and the 2SRI model, which accounts for potential unobserved confounding, further increased the difference to C\$419 (95% CI: C\$367, C\$472). During the late

follow-up period (10–14 years), the association reversed, and immigrants had lower annual healthcare costs than non-immigrants in both the observed (AMd: -C\$242; 95% CI: -C\$306; -C\$174) and the 2SRI-adjusted (AMd: -C\$165; 95% CI: -C\$251; -C\$74) models.

Among individuals aged 41 to 60 years in their first follow-up, immigrants had significantly lower healthcare costs than non-immigrants in unadjusted analyses throughout the follow-up period. During the first five years, the unadjusted mean difference reached -C\$847 (95% CI: -C\$1088, -C\$565). However, after adjusting for observed covariates, no significant difference was found (-C\$58, 95% CI: -C\$168, C\$60). Interestingly, the two-stage residual inclusion (2SRI) model reversed this trend, indicating that immigrants incurred higher costs (C\$351, 95% CI: C\$210, C\$503). Both unadjusted and covariate-adjusted models indicate significantly lower annual healthcare costs for immigrants, with pronounced mean differences between immigrants and non-immigrants during the mid- and late-follow-up periods.

After applying 2SRI, the cost differences between immigrants and non-immigrants were further attenuated and no longer statistically significant during the middle and late follow-up periods.

Table 3.5 presents the odds ratios of healthcare use between immigrants and non-immigrants across the follow-up period. For physician care, unadjusted analyses indicated lower odds ratios of use among immigrants than among non-immigrants across all follow-up periods (OR=0.66; 95% CI: 0.65, 0.67 in 0-4 years; OR=0.73; 95% CI: 0.72, 0.74 in 11-15 years). While 2SRI estimates reversed direction, indicating higher odds ratios of physician care use among immigrants in all periods (0–4 years: OR = 1.55, 95% CI: 1.51–1.59; and in 10–14 years: OR = 1.28, 95% CI: 1.24–1.32). This pattern suggests substantial selection and unobserved confounding in the unadjusted and conventional models.

Table 3.5: Unadjusted and adjusted odds ratios for annual healthcare use between immigrants and non-immigrants by healthcare services

Follow-up time groups	Unadjusted* ORs (95% CI)	Adjusted** ORs (95% CI)	Adjusted*** ORs (95% CI)
Physician care			
Coverage initial period (0 - 4 years)	0.66 (0.65, 0.67)	0.84 (0.83, 0.85)	1.55 (1.51, 1.59)
Mid follow-up period (5 –9 years)	0.73 (0.72, 0.74)	0.76 (0.75, 0.77)	1.37 (1.33, 1.40)
Late follow-up period (10 –14 years)	0.73 (0.72, 0.74)	0.72 (0.70, 0.73)	1.28 (1.24, 1.32)
Inpatient Care			
Coverage initial period (0 - 4 years)	1.00 (0.99, 1.02)	1.23 (1.21, 1.24)	1.10 (1.04, 1.16)
Mid follow-up period (5 –9 years)	0.72 (0.71, 0.74)	0.77 (0.75, 0.79)	0.69 (0.65, 0.74)
Late follow-up period (10 –14 years)	0.55 (0.53, 0.58)	0.49 (0.46, 0.53)	0.44 (0.39, 0.49)
Day Surgery			
Coverage initial period (0 - 4 years)	0.51 (0.50, 0.52)	0.67 (0.66, 0.68)	0.59 (0.57, 0.61)
Mid follow-up period (5 –9 years)	0.54 (0.53, 0.55)	0.61 (0.60, 0.63)	0.55 (0.52, 0.57)
Late follow-up period (10 –14 years)	0.58 (0.57, 0.59)	0.64 (0.62, 0.66)	0.57 (0.54, 0.60)
Emergency Department Care			
Coverage initial period (0 - 4 years)	5.01 (4.91, 5.13)	4.60 (4.49, 4.71)	3.74 (3.57, 3.93)
Mid follow-up period (5–9 years)	2.54 (2.48, 2.59)	2.26 (2.20, 2.32)	1.86 (1.77, 1.96)
Late follow-up period (10 –14 years)	2.31 (2.24, 2.38)	2.00 (1.92, 2.09)	1.67 (1.56, 1.78)
Government Funded Drug			
Coverage initial period (0 - 4 years)	0.40 (0.39, 0.41)	0.82 (0.80, 0.83)	1.04 (1.00, 1.09)
Mid follow-up period (5–9 years)	0.40 (0.39, 0.41)	0.73 (0.71, 0.75)	0.93 (0.89, 0.97)
Late follow-up period (10 –14 years)	0.45 (0.43, 0.46)	0.76 (0.73, 0.79)	0.97 (0.91, 1.02)

*The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

** Adjusted for age at start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

** * Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at the start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, and the residuals of the first regression. The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

Models were analyzed using the Generalized Estimating Equations (GEE) model with logistic regression for the population.

For inpatient care, unadjusted estimates showed no significant difference in the initial period, followed by progressively lower odds ratios among immigrants in later periods (OR=0.72; 95% CI: 0.71, 0.74 in the mid follow-up period and OR=0.55; 95% CI: 0.53, 0.58 in the late follow-up period). After adjustment, estimates changed direction in the early period in the 2SRI model (OR = 1.10, 95% CI: 1.04–1.16), while lower odds ratios persisted during mid and late follow-up (5–9 years: OR = 0.69; 95% CI: 0.65, 0.74, and in 10–14 years: OR = 0.44; 95% CI: 0.39, 0.49). This indicates a decrease in inpatient use among immigrants over time, particularly in later follow-up.

For day surgery, immigrants consistently had lower odds ratios of use across all follow-up periods in unadjusted models (ORs 0.51 to 0.58). Adjustment reduced but did not eliminate these differences, with 2SRI estimates remaining lower odds throughout follow-up (0–4 years: OR = 0.59; 95% CI: 0.57, 0.61, and in 10–14 years: OR = 0.57; 95% CI: 0.54, 0.60), suggesting persistently lower utilization among immigrants even after accounting for observed and unobserved confounding.

For emergency department (ED) care, immigrants consistently had substantially higher odds ratios of ED visits than non-immigrants in unadjusted analyses (OR = 5.01; 95% CI: 4.91,

5.13 in years 0–4). Although adjustment attenuated these estimates, the odds ratios for ED visits remained significantly higher among immigrants than among non-immigrants across all models. In the 2SRI model, immigrants continued to have higher ED visits, although the magnitude was reduced over time (0–4 years: OR = 3.74, 95% CI: 3.57, 3.93; 10–14 years: OR = 1.67, 95% CI: 1.56, 1.78). This suggests robust, higher reliance on emergency services among immigrants, even after accounting for confounding factors.

For government-funded drug use, unadjusted analyses showed significantly lower odds ratios among immigrants across the follow-up period (OR = 0.40; 95% CI: 0.39, 0.41 in 0–4 years and 0.45; 95% CI: 0.43, 0.46 in 11–15 years). After adjusting for observed covariates, estimates moved closer to no effect, and in the 2SRI models, the association was entirely attenuated during early and late follow-up, except in the mid follow-up (5–9 years: OR = 0.93, 95% CI: 0.89, 0.97). In late follow-up, estimates were near null (OR = 0.97, 95% CI: 0.91, 1.02), indicating very minimal difference in drug coverage use after accounting for confounding.

Analysis for healthcare services use stratified by baseline age in Appendix III.3 using the GEE multivariate logit model shows that Immigrants typically used fewer healthcare services than non-immigrants, including inpatient care, day surgery, physician consultations, and publicly funded medications. This trend was especially notable among individuals aged 41 to 60 at baseline, particularly for inpatient and physician care. In contrast, immigrants used emergency department services more frequently, particularly during the initial years of follow-up.

Analysis for healthcare use among young adults and older adults by sex in Appendix III.4 presents odds ratios for inpatient hospital admission between immigrants and non-immigrants, by sex, among the baseline age groups. There is a significant interaction between immigrant status and sex within age groups ($p < 0.0001$ for ages 21–40 and $p = 0.004$ for ages 41–60).

Among individuals aged 21–40 years at the first year of follow-up, inpatient care utilization differed by sex over the follow-up period. For males, immigrants consistently had lower odds of inpatient care than non-immigrants across all follow-up periods in unadjusted and adjusted analyses. In the adjusted 2SRI model, the odds ratios were 0.49 (95% CI: 0.45, 0.53) during years the first five years, and 0.43 (95% CI: 0.38, 0.50) during years 10–14.

Among females aged 21–40 years at first follow-up, immigrants had higher odds of inpatient care than non-immigrants during the initial follow-up period (adjusted OR = 1.51, 95% CI: 1.48, 1.54). However, this difference attenuated over time, with no significant difference observed during years 5–9 (adjusted OR = 0.99, 95% CI: 0.97, 1.02). During years 10–14, immigrant females had lower odds of inpatient care than non-immigrants (adjusted OR = 0.65, 95% CI: 0.61, 0.69). Among individuals aged 41–60 years at first follow-up, immigrants consistently had lower odds of inpatient care than non-immigrants across all follow-up periods and for both sexes.

For males, the fully adjusted 2SRI odds ratios were 0.34 (95% CI: 0.24, 0.49) during years 0–4, 0.28 (95% CI: 0.18, 0.43) during years 5–9, and 0.29 (95% CI: 0.15, 0.56) during years 10–14. For females, the corresponding odds ratios were 0.58 (95% CI: 0.52, 0.65), 0.42 (95% CI: 0.37, 0.47), and 0.44 (95% CI: 0.38, 0.52), respectively.

Table 3.6 presents unadjusted and adjusted mean differences in annual healthcare costs across the follow-up by sex. The stratified analysis among young adults by sex within the baseline age groups shows a significant interaction between immigrant status and sex (p-value = 0.0001 in the adjusted model).

Table 3.6: Trajectories of unadjusted and adjusted mean differences in annual healthcare costs between immigrants and non-immigrants, stratified by sex

Follow-up time groups	Males			Females		
	Unadjusted* mean differences (95% CI) *	Adjusted** mean differences (95% CI) *	Adjusted*** mean differences (95% CI) *	Unadjusted* mean differences (95% CI) *	Adjusted** mean differences (95% CI) *	Adjusted*** mean differences (95% CI) *
Baseline age 21 – 40 (<.0001)^a						
Initial period (0 - 4 yrs)	0.18 (-45, 50)	79 (41, 119)	106 (61, 152)	377 (312, 445)	622 (590, 654)	666 (629, 704)
Mid follow-up (5 – 9 yrs)	-29 (-119, 72)	73 (23, 126)	104 (47, 166)	116 (16, 223)	191 (135, 249)	233 (174, 295)
Late follow-up (10 – 14yrs)	-318 (-465, -152)	-126 (-207, -40)	-95 (-184, 0.72)	161 (-187, 581)	-344 (-417, -267)	-301 (-379, -222)
Baseline age 41 – 60 (0.63)^a						
Initial period (0 - 4 yrs)	-222 (-306, -128)	11 (-118, 152)	222 (57, 403)	-1232 (-1755, -521)	-135 (-249, -13)	172 (-9, 373)
Mid follow-up (5 – 9 yrs)	-1204 (-1404, -976)	-357 (-486, -218)	-120 (-288, 63)	-2790 (-3596, -1732)	-279 (-425, -119)	37 (-175, 275)
Late follow-up (10 – 14 yrs)	-2252 (-3039, -1212)	-621 (-756, -478)	-338 (-502, -163)	-5424 (-7124, -2887)	-472 (-643, -282)	-150 (-383, 113)

*The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

** Adjusted for age at start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

*** Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at the start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, urban/rural residence, and residuals of the first regression. The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

Models were analyzed using the Generalized Estimating Equations (GEE) model with a log-gamma distribution for the hurdle model.

^a p-value of interaction between immigrant status and sex.

Among males aged 21–40 years, there were no significant unadjusted differences in annual healthcare costs between immigrants and non-immigrants during the initial (UMd = C\$0.18, 95% CI: –C\$45, C\$50) and mid-follow-up periods (UMd = –C\$29, 95% CI: –C\$119, C\$72). However, after adjusting for observed covariates and using 2SRI, immigrants had significantly higher annual healthcare costs than non-immigrants during the first 10 years of follow-up (0–4 years: AMd = C\$106, 95% CI: C\$61, C\$152; 5–9 years: AMd = C\$104, 95% CI: C\$47, C\$166). In the late follow-up period (10–14 years), immigrants had lower annual healthcare costs than non-immigrants (AMD = –C\$95, 95% CI: –C\$184, C\$0.72), although the confidence interval suggests little or no difference.

Among females aged 21–40 years, immigrants had significantly higher annual healthcare costs than non-immigrants during the initial and mid-follow-up periods, in both unadjusted and adjusted models. In the adjusted 2SRI model, the mean differences were C\$666 (95% CI: C\$629, C\$704) during years 0–4 and C\$233 (95% CI: C\$174, C\$295) during years 5–9. During years 10–14, the association reversed, with immigrants having lower annual healthcare costs than non-immigrants (AMD = –C\$301, 95% CI: –C\$379, C\$ –222).

Among males aged 41–60 years, immigrants initially appeared to have lower healthcare costs than non-immigrants in unadjusted analyses, with differences increasing over time (years 10–14: UMd = –C\$2252, 95% CI: –C\$3039, –C\$1212). However, these differences were significantly reduced after adjustment. In the 2SRI model, immigrants incurred higher healthcare costs during years 0–4 (AMd = C\$222, 95% CI: C\$57, C\$403), but in years 10–14, they had lower costs (AMd = –C\$338, 95% CI: –C\$502, –C\$163). Among females aged 41–60 years, immigrants had lower costs throughout follow-up. These differences decreased considerably after adjustment. In the adjusted 2SRI model, there were no significant differences in annual

healthcare costs between immigrants and non-immigrants across the follow-up period. The influence of selection and unobserved confounding was more noticeable among immigrants aged 41–60 years than those aged 21–40 years, as shown by the significant reduction in cost differences after 2SRI adjustment in the older group.

3.4.2 Backward Analysis

Among both immigrants and non-immigrants in Table 3.7, average annual healthcare costs increased as individuals approached death. In the year of death, the average cost for immigrants was C\$53,916, and for non-immigrants, C\$42,900, decreasing progressively in each preceding year. Among the study population, sex distribution was roughly equal. Females had higher average annual healthcare costs (C\$12,909) than males (C\$10,426).

Among the study population, about 41% were married or had a common-law partner. Over a 10-year backward follow-up, married individuals had lower average annual healthcare costs (C\$9,443) than unmarried individuals (C\$13,695). Urban residents (61% of the population) had higher annual healthcare costs than rural residents (C\$13,743 vs C\$8,525), and a greater proportion of immigrants (88%) lived in urban areas compared with non-immigrants. During the follow-up period, individuals with more comorbidities had higher average annual costs (C\$3,474 for those without comorbidities vs C\$59,993 for 4 or more comorbidities). Among Manitoba residents, individuals who received employment and income assistance (C\$12,540 vs C\$11,656) or rent assistance (C\$14,959 vs C\$11,604) had higher average annual healthcare costs than those who did not receive. Among immigrants, those from Africa (\$17,430 for North and East Africa; \$20,974 for Sub-Saharan Africa) had the highest annual costs during the follow-up period, compared with those from other regions.

Table 3.7: Socio-demographic characteristics and average annual healthcare costs (AC) during January 1995–March 2023

Characteristics	All			Immigrants			Non-Immigrants		
	N	%	AC(C\$)	N	%	AC(C\$)	N	%	AC (C\$)
All*	222786		11690	4159	1.9	10474	218627	98.1	11714
Age at start of follow-up									
21 – 30	390	0.18	4215	31	0.75	9694	359	0.16	3951
31 – 40	3258	1.46	5273	192	4.62	8150	3066	1.40	5107
41 – 50	9389	4.21	6116	525	12.6	10822	8864	4.05	5884
51 – 60	17969	8.07	6440	680	16.4	8040	17289	7.9	6399
61 - 70	35649	16.0	8048	671	16.1	10254	34978	16.0	8009
71 - 80	59113	26.6	11428	981	23.6	11057	58132	26.6	11434
81 - 90	70661	31.7	17384	855	20.5	12420	69806	31.9	17438
91 - above	26357	11.8	22707	224	5.4	16832	26133	12.0	22755
Follow-up time									
0 (Year of death)	222786	100	43106	4159	1.87	53916	218627	98.13	42900
-1	222786	100	11723	4159	1.87	10340	218627	98.13	11749
-2	222786	100	9845	4159	1.87	7467	218627	98.13	9890
-3	213235	100	8742	3948	1.85	5414	209287	98.15	8804
-4	203507	100	8162	3757	1.85	3965	199750	98.15	8241
-5	193885	100	7269	3564	1.84	3549	190321	98.16	7339
-6	184359	100	6273	3351	1.82	3009	181008	98.18	6333
-7	175007	100	5609	3178	1.82	2502	171829	98.18	5666
-8	165687	100	4982	2988	1.80	2264	162699	98.20	5032
-9	156465	100	3923	2793	1.79	2020	153672	98.21	3958
Sex									
Male	109603	49.2	10426	2154	51.8	9100	107449	49.2	10452
Female	113183	50.8	12909	2005	48.2	11932	111178	50.8	12926
Having Married/ Common-Law Partner									
Yes	90464	40.6	9443	2155	51.8	9868	88309	40.0	9434
No	132322	59.4	13695	2004	48.2	11221	130318	60.0	13734
Residence at the end of follow-up									
Rural Residence	86407	38.8	8525	470	11.3	10264	85937	39.3	8516
Urban Residence	136379	61.2	13743	3689	88.7	10499	132690	60.7	13833
Comorbidity Index									
0	68237	30.6	3474	1481	35.6	1609	66756	30.5	3718
1 - 2	83987	37.7	12342	1299	31.2	9334	82688	37.8	12390

Characteristics	All			Immigrants			Non-Immigrants		
	N	%	AC(C\$)	N	%	AC(C\$)	N	%	AC (C\$)
3 - 4	32306	14.5	28015	501	12.1	33619	31805	14.6	27931
4+	38256	17.2	59993	878	21.1	71570	37378	17.1	59714
Employment/ Income Assistance									
Yes	7759	3.48	12540	247	5.9	9871	7512	3.4	11689
No	215027	96.5	11656	3912	94.1	19196	211115	96.6	12332
Rent Assistance									
Yes	4090	1.8	14959	148	3.6	10436	3942	1.8	11625
No	218696	98.2	11604	4011	96.4	11066	214685	98.2	15135
Immigration Characteristics of the Immigrant Population									
Refugee									
Yes				531	12.8	10532			
No				3628	87.2	10466			
Admission Category									
Economic Immigrant				1009	24.3	11370			
Family Class				2521	60.5	10011			
Refugee				531	12.8	10532			
Other Immigrant				98	2.4	13448			
Region of Origin									
Southeast Asia				1524	36.6	9597			
South Asia				477	11.5	11178			
Rest of Asia				448	10.8	9628			
East Europe				492	11.8	10515			
Rest of Europe				474	11.4	9914			
North and East Africa				128	3.1	17430			
Sub-Saharan Africa				84	2.0	20974			
North America and Oceania				182	4.4	14254			
Latin America and Caribbean				350	8.4	8679			

* The first two rows and time trends rows represent row% and the remainder column %

Table 3.8 shows the cumulative average healthcare costs of immigrants and non-immigrants, starting from the year of death and moving backward. Cumulative healthcare costs progressively increased with greater distance from the year of death among both immigrants and non-immigrants. In the year of death, the average cumulative costs were higher for immigrants than for non-immigrants (53,916; 95% CI: 48,169-59,663 versus 42,900; 95% CI: 41,791–44,009).

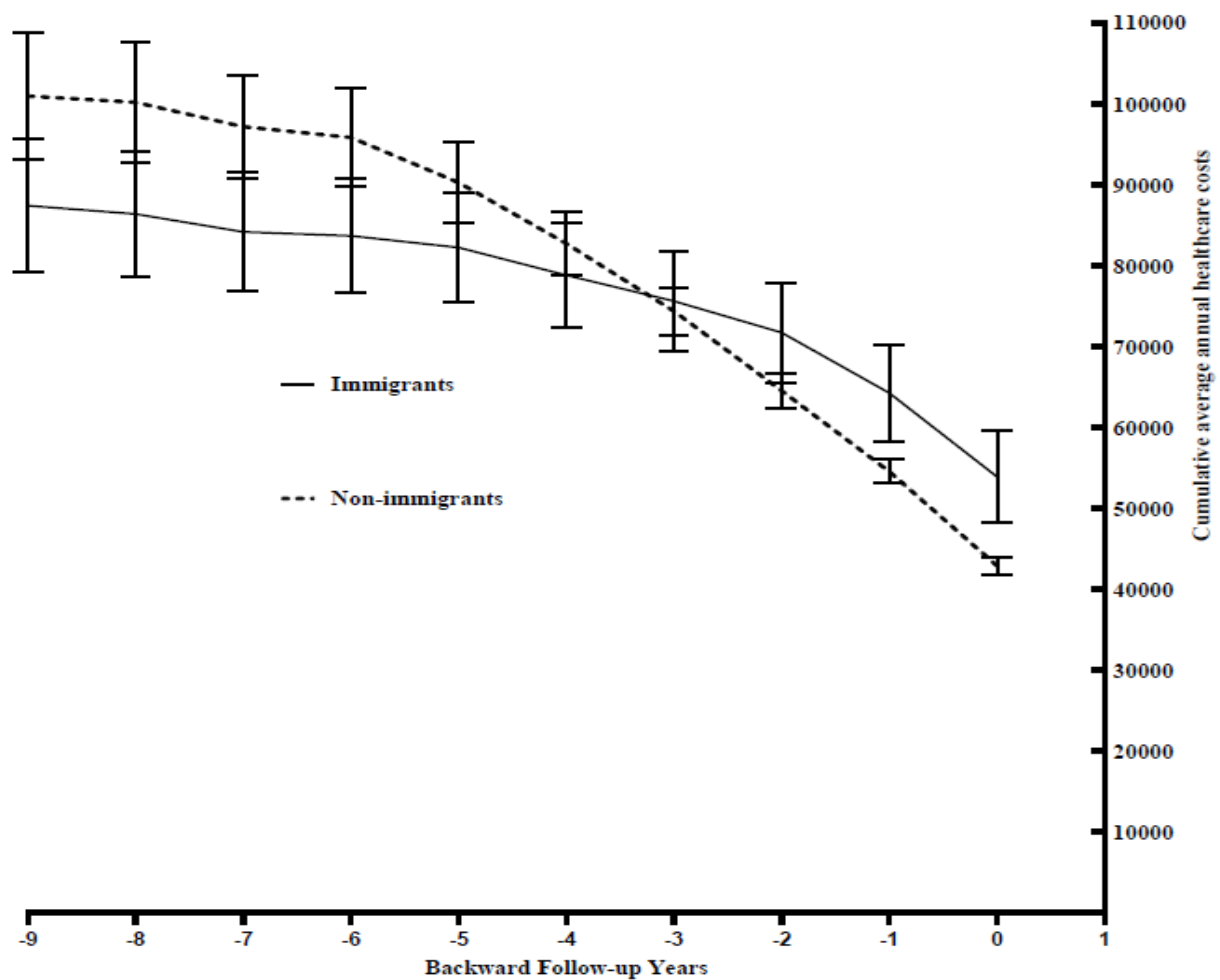
Table 3.8: Trends in cumulative average annual healthcare service costs with 95% CI over the last 10 years of follow-up: Immigrants vs. Non-Immigrants

Follow-up time	Immigrants	Non-immigrants	Differences (95% CI)
0 (Year of death)	53916	42900	11016 (5165, 16867)
-1	64256	54549	9707 (3597, 15817)
-2	71724	64540	7184 (662, 13706)
-3	75611	74395	1216 (-5588, 8020)
-4	78812	82730	-3918 (-11476, 3641)
-5	82232	90271	-8039 (-16497, 419)
-6	83688	95833	-12145 (-21461, -2829)
-7	84182	97186	-13004 (-22761, 3247)
-8	86378	100191	-13813 (-24525, -3101)
-9	87409	100963	-13554 (-24922, -2186)

The average cumulative costs were higher among immigrants in the 3 years prior to death than among non-immigrants, but lower from the 6th year backward. The cumulative cost trend in Figure 3.4 shows that immigrants' cumulative healthcare costs were higher than those of non-immigrants 3 to 4 years before death, suggesting higher costs near the end-of-life. Conversely, non-immigrants accumulated costs over a longer period leading up to their deaths.

Table 3.9 shows unadjusted and adjusted annual healthcare cost differences between immigrants and non-immigrants, starting from the year of death and moving backward. Annual healthcare costs exhibited notable differences between immigrants and non-immigrants over the ten years leading up to death.

Figure 3.4: Trend of cumulative average over the last 10 years of life among immigrants and non-immigrants



In the year of death, immigrants incurred significantly higher average healthcare costs than their non-immigrant counterparts, with figures of CA\$60,535 compared to CA\$44,944. This resulted in an unadjusted mean difference (UMd) of CA\$15,591 (95% CI: 9,220 – 22,711). After accounting for observed covariates, this difference increased to CA\$23,549 (95% CI: 14,397–34,212). Additionally, the 2SRI-adjusted mean healthcare cost difference remained higher among immigrants, standing at CA\$14,108 (95% CI: 7,332–21,934).

In contrast, throughout all the years leading up to death, immigrants consistently had lower annual healthcare costs compared to non-immigrants, except for the year immediately

before death. The 2SRI-adjusted model shows that the difference was CA\$−4,217 (95% CI: −4,847 to −3,493) in the fourth year prior to death, indicating significantly lower costs for immigrants. These negative differences persisted throughout the rest of the follow-up period, ranging from CA\$−2,062 to CA\$−3,519 in the 2SRI-adjusted analyses.

Table 3.10 presents the mean differences in healthcare costs by healthcare services from the year of death backward. The table shows that in the years immediately preceding death, immigrants incurred higher costs for physician care compared to non-immigrants. According to the fully adjusted 2SRI model, the mean difference in costs was C\$723 (95% CI: C\$447, C\$1,029) in the year of death, and C\$118 (95% CI: C\$47, C\$193) one year prior.

However, beginning two years before death, these differences began to decrease, eventually becoming negative from three years before death onward. The adjusted mean differences ranged from -C\$91 (95% CI: -C\$142, -C\$38) at three years before death to -C\$147 (95% CI: -C\$197, -C\$95) at seven years prior, indicating that physician care costs were lower among immigrants during the more distant pre-death period.

The data also shows that in the year of death, immigrants incurred significantly higher inpatient care costs (AMd = C\$9,078, 95% CI: C\$863, C\$18,924). No notable differences in costs were found one year prior to death. However, starting from two years before death, immigrants consistently demonstrated lower inpatient care costs compared to non-immigrants. The most substantial adjusted differences were observed four years prior to death (AMd = C\$−2,803, 95% CI: -C\$3,193, -C\$2,337), with these negative differences continuing up to nine years before death.

In the year of death, immigrants faced slightly higher day-surgery costs (AMd = C\$71; 95% confidence interval: C\$19, C\$133). However, no significant differences were found over

the three years preceding death. Between four and seven years prior to death, immigrants experienced significantly lower day surgery costs compared to non-immigrants, with adjusted mean differences ranging from -C\$43 (95% CI: -C\$66, -C\$14) to -C\$54 (95% CI: -C\$74, C\$30). The differences observed in the most distant years before death were not statistically significant.

Table 3.9: Trajectories of average annual healthcare costs from the year of death backward among immigrants and non-immigrants who died between January 1997 and March 2023

Follow-up time	Immigrants Unadjusted mean Costs (CA\$)	Non-immigrants Unadjusted mean Costs (CA\$)	Unadjusted mean differences (95% CI) *	Adjusted mean differences (95% CI) **	Adjusted mean differences (95% CI) ***
0 (Year of death)	60535	44944	15591 (9220, 22711)	23549 (14397, 34212)	14108 (7332, 21934)
-1	11612	12332	-720 (-1810, 481)	-158 (-1561, 1382)	-916 (-1985, 269)
-2	8390	10346	-1956 (-3465, -115)	-2614 (-4281, -671)	-2549 (-3830, -1030)
-3	5873	9042	-3169 (-3923, -2305)	-3827 (-4785, -2750)	-3285 (-4006, -2466)
-4	4328	8312	-3984 (-4599, -3268)	-5117 (-5948, -4173)	-4217 (-4847, -3493)
-5	3793	7227	-3433 (-4098, -2627)	-4130 (-5110, -2975)	-3519 (-4244, -2655)
-6	3139	6099	-2961 (-3545, -2243)	-3266 (-4417, -1837)	-2813 (-3695, -1694)
-7	2515	5512	-2997 (-3486, -2391)	-3798 (-4671, -2734)	-3112 (-3776, -2294)
-8	2292	4844	-2551 (-3056, -1904)	-2714 (-3694, -1485)	-2265 (-3006, -1325)
-9	2096	3776	-1681 (-2176, -1031)	-2309 (-3240, -1116)	-2062 (-2729, -1203)

*The model incorporated the first-order autoregressive AR (1) within-subject correlation.

** Adjusted for age at year of death, squared age at year of death, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation.

*** Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at year of death, squared age at year of death, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, urban/rural residence, and residuals of the first regression. The model incorporated a first-order autoregressive (AR1) within-subject correlation.

Models were analyzed using the Generalized Estimating Equations (GEE) model with a log-gamma distribution for the hurdle model.

Table 3.10: Unadjusted and adjusted mean differences in annual healthcare costs between immigrants and non-immigrants by healthcare services

Follow-up time	Unadjusted* mean differences (95% CI)	Adjusted** mean differences (95% CI)	Adjusted*** mean differences (95% CI)
Physician care			
0 (Year of death)	1379 (1080, 1702)	1061 (685, 1475)	723 (447, 1029)
-1	384 (296, 476)	200 (99, 305)	118 (47, 193)
-2	129 (64, 198)	-34 (-117, 51)	-42 (-100, 18)
-3	87 (23, 154)	-112 (-183, -38)	-91 (-142, -38)
-4	-11 (-60, 41)	-174 (-238, -109)	-140 (-186, -94)
-5	-29 (-79, 24)	-141 (-221, -57)	-110 (-168, -49)
-6	-33 (-84, 21)	-186 (-258, -110)	-142 (-193, -87)
-7	-54 (-100, -6)	-194 (-264, -120)	-147 (-197, -95)
-8	-69 (-108, -26)	-190 (-256, -121)	-144 (-191, -94)
-9	-37 (-80, 9)	-170 (-238, -99)	-131 (-179, -80)
Inpatient Care			
0 (Year of death)	9791 (4416, 15892)	15653 (2021, 31961)	9078 (863, 18924)
-1	-279 (-933, 459)	-1071 (-2871, 1073)	-867 (-1988, 480)
-2	-351 (-1480, 1206)	-3359 (-4578, -1894)	-2167 (-2935, -1239)
-3	-800 (-1172, -368)	-3460 (-4451, -2253)	-2258 (-2856, -1534)
-4	-1342 (-1590, -1048)	-4408 (-5038, -3657)	-2803 (-3193, -2337)
-5	-751 (-1091, -308)	-2734 (-3955, -1002)	-1720 (-2509, -584)
-6	-503 (-747, -195)	-500 (-2990, 4436)	-412 (-1905, 2515)
-7	-488 (-706, -203)	-1980 (-2758, -939)	-1255 (-1733, -617)
-8	-361 (-596, -41)	-613 (-1902, 1287)	-385 (-1222, 867)
-9	-238 (-449, 50)	-1199 (-2080, 24)	-784 (-1321, -42)
Day Surgery			
0 (Year of death)	115 (42, 203)	112 (35, 205)	71 (19, 133)
-1	20 (-18, 62)	13 (-27, 59)	5 (-23, 37)
-2	-19 (-48, 13)	-32 (-62, 3)	-23 (-44, 0.26)
-3	-6 (-41, 34)	-14 (-50, 29)	-9 (-34, 21)
-4	-50 (-87, -8)	-59 (-100, -12)	-46 (-73, -15)
-5	-56 (-87, -21)	-65 (-98, -27)	-45 (-68, -18)
-6	-48 (-81, -9)	-57 (-92, -16)	-43 (-66, -14)
-7	-67 (-93, -35)	-77 (-105, -43)	-54 (-74, -30)
-8	-26 (-61, 16)	-33 (-69, 11)	-24 (-48, 6)
-9	-11 (-48, 33)	-20 (-57, 24)	-15 (-41, 15)
Emergency Department Care			
0 (Year of death)	496 (406, 596)	522 (392, 673)	384 (284, 502)
-1	14 (7, 23)	13 (5, 23)	8 (2, 15)
-2	4 (-0.44, 11.5)	4 (-0.70, 11)	3 (-0.83, 8)
-3	1.9 (-0.25, 4.8)	3.6 (-0.21, 9)	3 (-0.24, 6)
-4	-0.82 (-1.8, 0.53)	-0.24 (-2.5, 2.9)	-0.14 (-1.8, 2.2)

-5	-0.64 (-1.37, 0.39)	-1.26 (-2.8, 0.86)	-0.99 (-2.1, 0.59)
-6	-0.46 (-1.09, 0.45)	-1.31 (-2.6, 0.44)	-1.07 (-1.97, 0.17)
-7	-0.25 (-0.74, 0.39)	-1.14 (-2.28, 0.38)	-0.86 (-1.74, 0.30)
-8	-0.13 (-0.56, 0.44)	-0.94 (-1.9, 0.27)	-0.71 (-1.43, 0.22)
-9	-0.32 (0.49, -0.12)	-1.30 (-1.8, -0.67)	-0.99 (-1.40, -0.50)
Government Funded Drug			
0 (Year of death)	429 (252, 623)	478 (257, 724)	421 (220, 644)
-1	278 (121, 450)	305 (111, 523)	274 (96, 473)
-2	158 (21, 310)	142 (-21, 318)	131 (-14, 293)
-3	25 (-69, 130)	15 (-98, 141)	15 (-91, 132)
-4	75 (-42, 209)	62 (-62, 204)	56 (-59, 187)
-5	19 (-72, 120)	23 (-86, 146)	22 (-79, 137)
-6	54 (-43, 167)	63 (-54, 200)	56 (-50, 180)
-7	12 (-61, 94)	19 (-72, 126)	20 (-67, 120)
-8	4 (-61, 80)	-0.99 (-73, 82)	0.12 (-67, 77)
-9	-12 (-63, 46)	-33 (-84, 25)	-30 (-78, 24)

*The model incorporated the first-order autoregressive AR (1) within-subject correlation.

** Adjusted for age at year of death, squared age at year of death, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation.

** * Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at year of death, squared age at year of death, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, urban/rural residence, and residuals of the first regression. The model incorporated a first-order autoregressive (AR1) within-subject correlation.

Models were analyzed using the Generalized Estimating Equations (GEE) model with logistic regression for the population.

The Table 3.10 also shows that immigrants had higher emergency department care costs in the year of their passing (AMd = C\$384, 95% CI: C\$284, C\$502) as well as in the year preceding their death (AMd = C\$8, 95% CI: C\$2, C\$15). Beyond this period, the cost differences were typically minor and not statistically significant.

In the context of government-funded drug expenditures, immigrants incurred higher costs in the year of death (AMd = C\$421, 95% CI: C\$220, C\$644) and in the year prior (AMd = C\$274, 95% CI: C\$96, C\$473). However, no statistically significant differences were found for the other years.

Appendix III.5 shows the unadjusted and adjusted ORs for healthcare service use in the last 10 years of their lives. The data show that immigrants had lower odds ratios of accessing physician care compared to non-immigrants during most of the 10 years before death. In the adjusted 2SRI model, the odds ratios for using physician care in the year of death were 47% lower (OR = 0.53, 95% CI: 0.44, 0.65) and remained significantly lower in most of the preceding years.

The data also show that in the year of death, immigrants had more than twice the odds of inpatient care use compared with non-immigrants (OR = 2.18, 95% CI: 1.92, 2.47). The higher odds ratios were also observed one year before death (OR = 1.28, 95% CI: 1.09, 1.5). From four to eight years before death, immigrants had significantly lower odds of inpatient care use than non-immigrants.

Immigrants consistently demonstrated lower odds of utilizing day surgery compared to non-immigrants throughout the pre-death period. In the 2SRI-adjusted model, the odds ratios ranged from 0.53 (95% CI: 0.44, 0.63) at the year of death to 0.75 (95% CI: 0.62, 0.91) nine years prior to death.

In case of emergency department care, immigrants were nearly twice as likely to use emergency department care compared to non-immigrants (OR = 1.92, 95% CI: 1.79, 2.06) in the year of death. However, in the years preceding death, immigrants had significantly lower odds of using emergency department services.

The results also show that in the adjusted model, it was found that immigrants were more likely than non-immigrants to utilize government-funded medications in the years leading up to death. The adjusted odds ratios showed a gradual decline, from 1.39 (95% CI: 1.30, 1.49) in the year of death to 1.13 (95% CI: 1.05, 1.21) four years prior to death.

3.5 Discussion

3.5.1 Main findings

3.5.1.1 Summary of the results of forward analysis

- 1) During the first 15 years of healthcare coverage in Manitoba, immigrants incurred lower cumulative healthcare costs than non-immigrants. This difference was especially evident among immigrants who started their coverage at an older adult age (41 -60).
- 2) A significantly smaller proportion of immigrants visited a physician, were admitted to a hospital, underwent day surgery, or utilized government-funded medications over the 15 years following immigration compared to non-immigrants. However, a higher proportion of immigrants sought care in emergency departments. These disparities were more pronounced among older adults.
- 3)) Among young adults, immigrants faced higher costs during the first 10 years of healthcare coverage. The unadjusted and adjusted cost models for older adults show that immigrants had significantly lower costs over a 15-year period. After adjusting for unobserved factors using instruments, the study found that immigrants had higher healthcare costs in the five years following their arrival. The unobserved confounders played a significant role in this variation.
- 4) Immigrants exhibited higher odds ratios for emergency department usage over the span of 15 years. Additionally, immigrants had significantly lower odds ratios of visiting a physician in both the unadjusted and adjusted models. However, in the 2SRI model, immigrants showed significantly higher odds ratios, highlighting the influence of unobserved variables on physician visits.

3.5.1.2 Summary of the results of backward analysis

- 1) Immigrants incurred significantly higher healthcare costs in the year of death compared to non-immigrants, but their total cumulative costs over the last 10 years of life were lower than those of non-immigrants.
- 2) The costs and use of inpatient care, emergency department services, and government-funded drugs were significantly higher among immigrants compared to non-immigrants in the year of death.
- 3) In the preceding years of death, immigrants were less likely to use healthcare services compared to non-immigrants and immigrants incurred lower healthcare costs.

3.5.2 Limitations

The study did not exclude hospitalizations of females related to childbirth, as these do not signify morbidity or poor health. Consequently, the differences in annual healthcare costs and usage may be skewed, especially in the initial years after immigrants arrive.

The study focuses exclusively on permanent residents and citizens among the foreign-born population, not including temporary residents.

Another limitation is that it does not follow the same immigrants from the start of health coverage to death, though most of them may include both forward- and backward-looking analyses. The study conducted a forward-looking analysis over 15 consecutive years after immigrants began their health coverage, and a backward-looking analysis from the year of death for the last 10 years of life.

Although instruments for endogeneity adjustment have fixed attributes and do not directly affect eligibility for healthcare services and associated costs in the universal system, there is an exception for refugee claimants. These individuals were covered by a federal program

while awaiting their permanent residency. Unfortunately, I could not differentiate them from the broader refugee group, though many were not refugee claimants.

Finally, although the study identifies that unobserved factors had a significant effect on immigrants' healthcare use and costs, it does not detail the specific pre- and post-immigration confounding factors. As a result, the study does not clarify what factors contribute to lower healthcare use and costs among immigrants.

3.5.3 Interpretation

3.5.3.1 Forward analysis

The forward analysis revealed that during the beginning years of Manitoba's healthcare coverage for immigrants, immigrants' annual healthcare costs were higher than those of non-immigrants. This cost disparity is especially pronounced among immigrants who began coverage at a young age, with female immigrants experiencing the largest differences. Furthermore, young female immigrants had significantly higher odds of utilizing inpatient hospital care in their initial years of coverage than their non-immigrant counterparts. The increased overall and inpatient healthcare costs observed among young female immigrants may be associated with their initial experiences related to fertility. Previous studies suggest that the probability of a first birth is higher among female immigrants in the years immediately after immigration, especially among those who immigrated through marriage (Wolf Katharina, 2016; Alicia Adsera, 2013; Jeylan, 2021). Statistics Canada reports that more than two out of five newborns had an immigrant mother, a rate nearly twice that in 1997 (Statistics Canada, 2025). The immigrants whose coverage began at an older age (41–60 years) had higher healthcare costs in the initial years than non-immigrants, after controlling for unobserved factors, though they had significantly lower costs, with large differences relative to non-immigrants in the unadjusted model. It suggested

that the significant cost differences seen in unadjusted models were mainly due to selection factors and confounding. In addition, results from the unobserved confounding adjustment also show that immigration at an older adult age was associated with a higher demand for physician care upon arrival, though they had fewer visits to physicians in the unadjusted and observed-adjusted models. The results show that selection and unobserved confounding are stronger among those who immigrated as older adults than among those who immigrated as young adults. Additionally, the study indicates that the differences in annual cumulative mean costs between immigrants and non-immigrants were greater among older adults. The findings are consistent with the study of Gubernskaya Zoya (2015). The author demonstrates that immigrants who arrived at an older age often faced prolonged exposure to challenging conditions in their home countries, which negatively impacted their health over the years since their immigration. Additionally, these individuals have fewer opportunities to assimilate into the host country and its healthcare system (Gubernskaya Zoya, 2015). The older immigrants faced both physical and mental health issues in the immediate years after their arrival, primarily due to the stress of integration, settlement challenges, changes in diet, and difficulties adapting to a new environment. They also encountered obstacles in navigating healthcare systems and accessing primary care, often stemming from language barriers and inadequate health literacy (Wang et al., 2019; Ahmed et al., 2016; Sanou et al., 2014; Thomson et al., 2015; Taylor et al., 2005).

3.5.3.2 Backward analysis

Consistent with Chapter 2 titled “Healthcare costs at the end-of-life among immigrants and non-immigrants, Manitoba, Canada”, this study found that among decedents, immigrants incurred significantly higher healthcare costs in their last year of life compared to non-immigrants. These increased costs included more use of inpatient care, emergency department visits, and

government-funded medications during the year of death. However, a retrospective 10-year lookback revealed that immigrants incurred considerably lower costs in the years leading up to their death. Also, these findings are consistent with previous studies indicating that immigrants are more likely to receive aggressive care in acute settings during their last year of life (Chu et al., 2021; Quach et al., 2021; Yarnell et al., 2017).

Contradictions: However, there is an apparent contradiction in the findings between the forward and backward analyses. The forward analysis indicated that immigrants incurred higher healthcare costs after their arrival, while this trend was not observed in the backward analysis. These discrepancies in the findings between forward and backward analysis may arise from the following factors. First, there are fewer decedents compared to the total population in the forward analysis. As a result, the higher costs associated with decedents cannot offset the lower costs of those who survived and were not yet closer to EOL. Consequently, combining a few decedents with many survivors, the costs incline towards the survivors. Conversely, the backward analysis is restricted to decedents. The second paradox is that, in the forward analysis among young adults, immigrants had higher odds of inpatient hospital care upon arrival than non-immigrants. This may be due to the failure to exclude maternity hospitalizations from healthcare service records. However, the study did not observe this pattern in the years prior to death in the backward analysis. Another paradox is that, in the forward analysis, immigrants had higher cumulative costs in the first few years after arrival, particularly among young adult immigrants.

3.6 Conclusion

The trajectories of healthcare utilization and associated costs differ between immigrants and non-immigrants, driven by factors such as age at the onset of healthcare coverage, sex and unobserved confounding factors. Young female immigrants exhibited higher costs and greater utilization of inpatient care during the initial years following their immigration compared to their young female non-immigrant counterparts. Additionally, the selection effects and unobserved factors influencing healthcare use and costs are more pronounced among older adult immigrants. While immigrants generally are more likely to seek healthcare after their arrival, these trends might be influenced by factors such as sampling methods, study design, duration of follow-up, the attrition of deceased individuals, and unobserved confounding variables. Notably, the study found that in the years leading up to death, immigrants tend to utilize healthcare services less frequently and incur lower costs over time. However, they demonstrate a heightened tendency to rely on inpatient care and emergency services in their final year of life, resulting in higher healthcare costs at the end-of-life compared to non-immigrants. Despite higher EOL costs, immigrants had a net lower overall lifetime cost.

3.7 References

- Ahmed, S., Shommu, N. S., Rumana, N., Barron, G. R. S., Wicklum, S., & Turin, T. C. (2016). Barriers to Access of Primary Healthcare by Immigrant Populations in Canada: A Literature Review. *Journal of Immigrant and Minority Health*, 18(6), 1522–1540.
- Alícia Adserà. (2013). *Fertility of Recent Immigrants to Canada*. IZA - Institute of Labor Economics.
- Baldi, I., Pagano, E., Berchialla, P., Desideri, A., Ferrando, A., Merletti, F., & Gregori, D. (2013). Modeling healthcare costs in simultaneous presence of asymmetry, heteroscedasticity and correlation. *Journal of Applied Statistics*, 40(2), 298–310.
- Barnett, E. D., Wheelock, A. B., MacLeod, W. B., McCarthy, A. E., Walker, P. F., Coyle, C. M., Greenaway, C. A., Castelli, F., López-Vélez, R., Gobbi, F. G., Trigo, E., Grobusch, M. P.,

- Gautret, P., Hamer, D. H., Kuhn, S., & Stauffer, W. M. (2023). Infections with long latency in international refugees, immigrants, and migrants seen at Geo Sentinel sites, 2016–2018. *Travel Medicine and Infectious Disease*, 56, Article 102653.
- Buntin, M. B., & Zaslavsky, A. M. (2004). Too much ado about two-part models and transformation? Comparing methods of modeling Medicare expenditures. *Journal of Health Economics*, 23(3), 525–542.
- Cheung, M. C., Earle, C., Fischer, H., Camacho, X., Saskin, R., Shah, B., Austin, P., and Singh, S. (2016). The impact of immigration status on cancer outcomes in Ontario, Canada. *Journal of Clinical Oncology*, 34(7_suppl): 285–285.
- Chu, A., Barbera, L., Sutradhar, R., Oz, U. E., O’Leary, E., & Seow, H. (2021). Association between end-of-life cancer care and immigrant status: A retrospective cohort study in Ontario, Canada. *BMJ Open*, 11(6).
- Chu A, Barbera L, Sutradhar R, et al. (2021). Association between end-of-life cancer care and immigrant status: a retrospective cohort study in Ontario, Canada. *BMJ. Open*.11: e042978.
- Castillo-Cañón, J. C., Bojorquez-Chapela, I., Fernández-Niño, J., Valbuena-García, A. M., & Acuña-Merchan, L. (2021). Healthcare-related expenditures among immigrants and non-immigrants living with HIV in Colombia. *Health & Social Care in the Community*, 29(6), 1887–1895.
- Castelli F, Sulis G. (2017). Migration and infectious diseases. *Clin Microbiol Infect*. 23(5):283289.
- Eurostat. *Migrants Integration Statistics – Health* (2025). Available online at: https://ec.europa.eu/eurostat/statistics-explained/index.php?title=Migrant_integration_statistics_-_health#Highlights (Accessed May 12, 2025).
- Grady, J. J., & Helms, R. W. (1995). Model selection techniques for the covariance matrix for incomplete longitudinal data. *Statistics in Medicine*, 14(13), 1397–1416.
- Gimeno-Feliu, L. A., Pastor-Sanz, M., Poblador-Plou, B., Calderón-Larrañaga, A., Díaz, E., & Prados-Torres, A. (2021). Overuse or underuse? Use of healthcare services among irregular migrants in a north-eastern Spanish region. *International Journal for Equity in Health*, 20(1), Article 41.
- Greenaway C, Castelli F. (2019). Infectious diseases at different stages of migration: an expert review. *Journal of Travel Medicine*. 26(2):taz007.
- Gubernskaya, Z. (2015). Age at Migration and Self-Rated Health Trajectories After Age 50: Understanding the Older Immigrant Health Paradox. *The Journals of Gerontology. Series B, Psychological Sciences and Social Sciences*, 70(2), 279–290.
- Gubernskaya, Z., Bean, F. D., & Van Hook, J. (2013). (Un)Healthy Immigrant Citizens: Naturalization and Activity Limitations in Older Age. *Journal of Health and Social Behavior*, 54(4), 427–443.

- Guo, M., Mourad, N., Karimuddin, A., & Sutherland, J. (2026). Comparing Preoperative Healthcare Utilization Between Immigrants and Non-Immigrants Undergoing Emergency General Surgery in British Columbia. *Journal of Immigrant and Minority Health*.
- Hernán, M. A., Hernández-Díaz, S., & Robins, J. M. (2004). A Structural Approach to Selection Bias. *Epidemiology* (Cambridge, Mass.), 15(5), 615–625.
- Hernán MA, Robins J. Causal Inference Book. Boca Raton, FL: Chapman & Hall/CRC; Forthcoming 2016.
- Holz, M. (2022). Health inequalities in Germany: differences in the “Healthy migrant effect” of European, non-European and internal migrants. *Journal of Ethnic and Migration Studies*, 48(11): 2620–2641.
- Howe, C. J., Cole, S. R., Lau, B., Napravnik, S., & Joseph J., E. 2016. Selection Bias Due to Loss to Follow Up in Cohort Studies. *Epidemiology* (Cambridge, Mass.), 27(1), 91–97.
- Jeylan Erman (2021). Three essays on migration and family change (doctoral dissertation). University of Pennsylvania.
- Jennum, P., Debes, N. M. M., Ibsen, R., & Kjellberg, J. (2021). Long-term employment, education, and healthcare costs of childhood and adolescent onset of epilepsy. *Epilepsy & Behavior*, 114(Pt A), Article 107256.
- Jo, M., Lee, Y., and Kim, T. (2023). Medical care costs at the end-of-life among older adults with cancer: a national health insurance data-based cohort study. *BMC Palliative Care*, 22(1): 76–76.
- Kumar, B. N., & Krasnik, A. (2020). A New Focus on Migration Health. In P. Nijkamp, K. Kourtit, M. Partridge, & B. Newbold (Eds.), *The Economic Geography of Cross-Border Migration* (pp. 335–355).
- Kumar, B. N., & Diaz, E. (2019). *Migration and health: Primary care perspective*. Boca Raton: Taylor and Francis.
- Kwon, Y., Choi, Y.-G., Park, T., Ziegler, A., & Paik, M. C. (2017). Generalized estimating equations with stabilized working correlation structure. *Computational Statistics & Data Analysis*, 106, 1–11.
- Lange, S., Glatz, T., & Eiset, A. H. (2024). Association of pre-migration socioeconomic status and post-migration mental health in Syrian refugees in Lebanon: a descriptive sex-stratified cross-sectional analysis. *Global Health Research and Policy*, 9(1), Article 9.
- Lebrun, L. A. (2012). Effects of length of stay and language proficiency on health care experiences among Immigrants in Canada and the United States. *Social Science and Medicine*, 74(7): 1062–1072.
- Liu, L., Huang, X., & O’Quigley, J. (2008). Analysis of Longitudinal Data in the Presence of Informative Observational Times and a Dependent Terminal Event, with Application to Medical Cost Data. *Biometrics*, 64(3), 950–958.

- Liang, K. Y., & Zeger, S. L. (1986). Longitudinal data analysis using generalized linear models. *Biometrika*, 73(1), 13–22.
- Loi, S., Li, P., & Myrskylä, M. (2025). Unequal weathering: How immigrants' health advantage vanishes over the life-course. *Journal of Migration and Health (Online)*, 11, Article 100303.
- Lu, Chaohui, and Edward Ng (2019). *Healthy Immigrant Effect by Immigrant Category in Canada*. Health Reports, vol. 30, no. 4, pp. 3–11
- Lu, Y., Kaushal, N., Denier, N., and Wang, J. S.-H. (2017). Health of newly arrived immigrants in Canada and the United States: Differential selection on health. *Health and Place*, 48: 1–10.
- McKinlay, J. B. (1975). Who is Really Ignorant--Physician or Patient? *Journal of Health and Social Behavior*, 16(1), 3–11.
- Malehi, A. S., Pourmotahari, F., & Angali, K. A. (2015). Statistical models for the analysis of skewed healthcare cost data: A simulation study. *Health Economics Review*, 5(11), Article 11.
- McDonald T. J., Kennedy S. (2005). Is migration to Canada associated with unhealthy weight gain? Overweight and obesity among Canada's immigrants. *Social Science and Medicine*, 61: 2469–2481.
- Mehta, N. K., Elo, I. T., Engelman, M., Lauderdale, D. S., & Kestenbaum, B. M. (2016). Life Expectancy Among U.S.-born and Foreign-born Older Adults in the United States: Estimates from Linked Social Security and Medicare Data. *Demography*, 53(4), 1109–1134.
- Mihaylova, B., Briggs, A., O'Hagan, A., & Thompson, S. G. (2011). Review of statistical methods for analysing healthcare resources and costs. *Health Economics*, 20(8), 897–916.
- Mills A. (2014). Health care systems in low- and middle-income countries. *The New England journal of medicine*, 370(6), 552–557.
- Müller, M., Khamis, D., Srivastava, D., Exadaktylos, A., & Pfortmueller, C. (2018). Understanding refugees' health. *Seminars in Neurology*, 38(2), 152–162.
- Nabi, H., Ibsen, R., Ibsen, M., Kjellberg, J., Hetland, M. L., & Glintborg, B. (2024). Counting the costs: a nationwide study on healthcare use following an adalimumab biosimilar switch in >1300 inflammatory arthritis patients. *Therapeutic Advances in Musculoskeletal Disease*, 16, 1759720X241289391.
- Ng E., Pottie K., Spitzer D. (2011). Official language proficiency and self-reported health among immigrants to Canada. *Health Reports*, 22(4): 15–23.
- Nkimbeng, M., Cudjoe, J., Turkson-Ocran, R.-A., Commodore-Mensah, Y., Thorpe, R. J., & Szanton, S. L. (2019). Disparities in the Prevalence and Correlates of Disability in Older Immigrants in the United States: A systematic Review of the Literature. *Journal of Racial and Ethnic Health Disparities*, 6(3), 552–562.

- Quach, B. I., Qureshi, D., Talarico, R., Hsu, A. T., & Tanuseputro, P. (2021). Comparison of End-of-Life Care Between Recent Immigrants and Long-standing Residents in Ontario, Canada. *JAMA Network Open*, 4(11), e2132397.
- Ravichandiran, N., Mathews, M., and Ryan, B. L. (2022). Utilization of healthcare by immigrants in Canada: a cross-sectional analysis of the Canadian Community Health Survey. *BMC Family Practice*, 23(1): 69–69.
- Rivera-Hernandez, M., Kumar, A., Chou, L.-N., Keeney, T., Ferdows, N., Karmarkar, A., Markides, K. S., & Ottenbacher, K. (2022). Healthcare utilization and costs among high-need and frail Mexican American Medicare beneficiaries. *PloS One*, 17(1), Article e0262079.
- Rosenthal, T. (2018). Immigration and Acculturation: Impact on Health and Well-Being of Immigrants. *Current Hypertension Reports*, 20(8), Article 70.
- Sanou, D., O'Reilly, E., Ngnie-Teta, I., Batal, M., Mondain, N., Andrew, C., Newbold, B. K., & Bourgeault, I. L. (2014). Acculturation and Nutritional Health of Immigrants in Canada: A Scoping Review. *Journal of Immigrant and Minority Health*, 16(1), 24–34.
- Schlagenhauf P, Grobusch MP, Hamer DH, et al. (2018). Area of exposure and treatment challenges of malaria in Eritrean migrants: a Geo Sentinel analysis. *Malaria J*.17:443.
- Shen, M. J., Prigerson, H. G., Tergas, A. I., and MacIejewski, P. K. (2019). Impact of immigrant status on aggressive medical care counter to patients' values near death among advanced cancer patients. *Journal of Palliative Medicine*, 22(1): 34–40.
- Statistics Canada (2025). The contribution of foreign-born mothers to Canadian births from 1997 to 2024.
- Taylor LE, Taylor-Henley S, Doan L. (2005). Older immigrants: language competencies and mental health. *Can J Commun Mental Health*, 24(2):23–33.
- Terza, J. V., Basu, A., & Rathouz, P. J. (2008). Two-stage residual inclusion estimation: Addressing endogeneity in health econometric modeling. *Journal of Health Economics*, 27(3), 531–543.
- Thomson, M. S., Chaze, F., George, U., & Guruge, S. (2015). Improving Immigrant Populations' Access to Mental Health Services in Canada: A Review of Barriers and Recommendations. *Journal of Immigrant and Minority Health*, 17(6), 1895–1905.
- Tzogiou, C., Boes, S., & Brunner, B. (2021). What explains the inequalities in health care utilization between immigrants and non-migrants in Switzerland? *BMC Public Health*, 21(1), Article 530.
- Vang Z, Sigouin J, Flenon A, Gagnon, A. (2015). *The Healthy Immigrant Effect in Canada: A Systematic Review*. Population Change and Life Course Strategic Knowledge Cluster Discussion Paper Series 2015; 3(1): Article 4.

- Wang, L., Guruge, S., & Montana, G. (2019). Older Immigrants' Access to Primary Health Care in Canada: A Scoping Review. *Canadian Journal on Aging*, 38(2), 193–209.
- Wanigaratne, S., Cole, D. C., Bassil, K., Hyman, I., Moineddin, R., & Urquia, M. L. (2015). Contribution of HIV to Maternal Morbidity Among Refugee Women in Canada. *American Journal of Public Health (1971)*, 105(12), 2449–2456.
- Wanigaratne, S., Shakya, Y., Gagnon, A. J., Cole, D. C., Rashid, M., Blake, J., Dastoori, P., Moineddin, R., Ray, J. G., & Urquia, M. L. (2018). Refugee maternal and perinatal health in Ontario, Canada: a retrospective population-based study. *BMJ Open*, 8(4), Article e018979
- Wilson, F. A., Zallman, L., Pagán, J. A., Ortega, A. N., Wang, Y., Tatar, M., & Stimpson, J. P. (2020). Comparison of Use of Health Care Services and Spending for Unauthorized Immigrants vs Authorized Immigrants or US Citizens Using a Machine Learning Model. *JAMA Network Open*, 3(12), e2029230.
- Wolf, K. (2016). Marriage Migration Versus Family Reunification: How Does the Marriage and Migration History Affect the Timing of First and Second Childbirth Among Turkish Immigrants in Germany? *European Journal of Population*, 32(5), 731–759.
- Yarnell, C. J., Fu, L., Manuel, D., Tanuseputro, P., Stukel, T., Pinto, R., Scales, D. C., Laupacis, A., & Fowler, R. A. (2017). Association between immigrant status and end-of-life care in Ontario, Canada. *JAMA - Journal of the American Medical Association*, 318(15), 1479–1488.
- Zimmerman, F. J., & Pronk, N. P. (2025). Socioeconomic milieu and culture: Forcing factors and the most fundamental determinant of health. *Progress in Cardiovascular Diseases*, 90, 62–70.
- Robins JM, Rotnitzky A, Zhao LP. (1995). Analysis of semiparametric regression models for repeated outcomes in the presence of missing data. *Journal of the American Statistical Association*. 90:106–121.
- Seaman S, Copas A. (2009). Doubly robust generalized estimating equations for longitudinal data. *Statistics in medicine*, 28:937–955.

Appendix III

Appendix III.1: Trends in average annual healthcare service costs with 95% CI: Immigrants (IM)
vs. Non-Immigrants (NIM)

Follow-up time groups	Coverage initial period (0 - 4 years)		Mid follow-up period (5 –9 years)		Late follow-up period (10 –14 years)	
Physician care	IM	NIM	IM	NIM	IM	NIM
All	416 (414, 418)	345 (344, 346)	492 (489, 494)	459 (458, 460)	568 (563, 572)	609 (607, 610)
Baseline age 20 - 40	416 (414, 418)	299 (298, 300)	468 (465, 471)	367 (366, 368)	506 (501, 511)	460 (459, 462)
Baseline age 41 - 60	414 (410, 418)	413 (411, 414)	558 (552, 565)	583 (580, 585)	730 (719, 741)	805 (802, 809)
Inpatient Care						
All	311 (298, 324)	328 (322, 333)	340 (325, 355)	644 (624, 663)	512 (457, 568)	1279 (1236, 1321)
Baseline age 20 - 40	327 (313, 342)	256 (251, 261)	306 (295, 317)	373 (361, 386)	381 (328, 433)	620 (589, 651)
Baseline age 41 - 60	261 (230, 292)	432 (421, 444)	434 (385, 483)	1008 (965, 1050)	859 (711, 1008)	2154 (2063, 2245)
Day Surgery						
All	45 (44, 46)	53 (53, 54)	67 (66, 69)	78 (78, 79)	89 (87, 91)	124 (123, 125)
Baseline age 20 - 40	41 (41, 42)	45 (44, 45)	60 (58, 61)	57 (56, 57)	74 (72, 76)	87 (86, 87)
Baseline age 41 - 60	56 (54, 58)	66 (65, 66)	89 (86, 92)	108 (107, 109)	129 (123, 134)	173 (172, 174)
Emergency Department Care						
All	11.32 (11,12)	2.28 (2.2, 2.4)	19.98 (19.5, 20.5)	6.56 (6.32, 6.81)	27.52 (26.3, 28.8)	12.88 (12.3, 13.5)
Baseline age 20 - 40	12.06 (11.8,12.3)	2.84 (2.7, 3.0)	20.67 (20.1, 21.2)	5.33 (5.04, 5.63)	26.32 (25.3, 27.4)	9.37 (8.5, 10.2)
Baseline age 41 - 60	9.07 (8.7, 9.4)	1.46 (1.37, 1.56)	18.07 (17.1, 19.0)	8.22 (7.81, 8.63)	30.68 (27.2, 34.2)	17.54 (16.7, 18.4)
Government Funded Drug						
All	69 (66, 71)	93 (91, 94)	137 (132, 142)	248 (246, 251)	214 (206, 223)	410 (404, 416)
Baseline age 20 - 40	53 (50, 55)	59 (58, 61)	104 (99, 109)	161 (157, 165)	157 (148, 167)	277 (267, 287)
Baseline age 41 - 60	117 (111, 123)	141 (139, 143)	228 (217, 239)	365 (362, 369)	364 (345, 383)	587 (581, 592)

Appendix III.2: Trajectories of unadjusted and adjusted mean differences in annual healthcare costs between immigrants and non-immigrants stratified by baseline age groups (P-value of interaction between age groups and immigrant status is <.0001).

Follow-up time groups	Baseline age: 21 – 40 years			Baseline age: 41 – 60 years		
	Unadjusted* mean differences (UMd, 95% CI) *	Adjusted** mean differences (AMd, 95% CI) *	Adjusted*** mean differences (AMd, 95% CI) *	Unadjusted* mean differences (UMd, 95% CI) *	Adjusted** mean differences (AMd, 95% CI) *	Adjusted*** mean differences (AMd, 95% CI) *
Coverage initial period (0 - 4 years)	199 (156, 243)	349 (321, 377)	419 (367, 472)	-847 (-1088, -565)	-58 (-168, 60)	351 (210, 503)
Mid follow-up period (5 – 9 years)	59 (-10, 131)	127 (88, 167)	201 (139, 266)	-2610 (-2987, -2171)	-313 (-455, --157)	111 (-78, 320)
Late follow-up period (10 – 14 years)	-59 (-262, 173)	-242 (-306, -174)	-165 (-251, -74)	-5517 (-6583, -4138)	-563 (-710, -403)	-116 (-314, 103)

*The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

** Adjusted for age at start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

*** Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at the start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, and urban/rural residence. The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW. Models were analyzed using the Generalized Estimating Equations (GEE) model with a log-gamma distribution for the hurdle model.

Appendix III.3: Unadjusted and adjusted odds ratios for annual healthcare use between immigrants and non-immigrants by healthcare services and baseline age groups

Follow-up time groups	Baseline age: 21 – 40 years			Baseline age: 41 – 60 years		
	Unadjusted* mean differences (UMd, 95% CI) *	Adjusted** mean differences (UMd, 95% CI) *	Adjusted*** mean differences (UMd, 95% CI) *	Unadjusted* mean differences (UMd, 95% CI) *	Adjusted** mean differences (UMd, 95% CI) *	Adjusted*** mean differences (UMd, 95% CI) *
Inpatient Care (>.0001) ^a						
Coverage initial period 0 - 4 years	1.09 (1.07, 1.10)	1.33 (1.31, 1.35)		0.42 (0.40, 0.44)	0.59 (0.56, 0.61)	0.37 (0.27, 0.50)
Mid follow-up period (5– 9 years)	0.86 (0.84, 0.88)	0.88 (0.86, 0.90)		0.44 (0.41, 0.49)	0.44 (0.41, 0.47)	0.28 (0.20, 0.40)
Late follow-up period (10 – 14 years)	0.65 (0.63, 0.68)	0.58 (0.54, 0.61)		0.45 (0.41, 0.49)	0.46 (0.38, 0.55)	0.30 (0.19, 0.46)
Day Surgery (0.03) ^a						
Coverage initial period 0 - 4 years	0.58 (0.57, 0.59)	0.66 (0.65, 0.67)	0.57 (0.55, 0.60)	0.49 (0.48, 0.51)	0.65 (0.63, 0.68)	0.58 (0.53, 0.63)
Mid follow-up period (5 – 9 years)	0.63 (0.62, 0.65)	0.63 (0.61, 0.64)	0.55 (0.53, 0.57)	0.53 (0.52, 0.55)	0.62 (0.60, 0.64)	0.55 (0.51, 0.59)
Late follow-up period (10 – 14 years)	0.70 (0.67, 0.72)	0.65 (0.63, 0.68)	0.57 (0.54, 0.61)	0.59 (0.57, 0.62)	0.65 (0.63, 0.68)	0.58 (0.52, 0.66)
Physician Care (>.0001) ^a						
Coverage initial period 0 - 4 years	0.79 (0.78, 0.80)	0.88 (0.87, 0.89)	1.45 (1.42, 1.49)	0.57 (0.56, 0.58)	0.70 (0.68, 0.71)	1.82 (1.73, 1.92)
Mid follow-up period (5 – 9 years)	0.96 (0.95, 0.97)	0.84 (0.83, 0.85)	1.36 (1.33, 1.40)	0.59 (0.57, 0.60)	0.58 (0.56, 0.59)	1.49 (1.41, 1.57)
Late follow-up period (10 – 14 years)	0.96 (0.94, 0.98)	0.81 (0.79, 0.83)	1.31 (1.26, 1.35)	0.55 (0.53, 0.57)	0.55 (0.52, 0.57)	1.42 (1.33, 1.51)
Emergency Dept. (0.04) ^a						

Coverage initial period 0 - 4 years	4.29 (4.19, 4.40)	3.86 (3.76, 3.97)	3.22 (3.11, 3.34)	6.34 (6.04, 6.66)	6.37 (6.04, 6.71)	5.24 (4.42, 6.22)
Mid follow-up period (5– 9 years)	2.77 (2.70, 2.84)	2.28 (2.23, 2.34)	1.92 (1.86, 1.99)	2.16 (2.08, 2.25)	2.28 (2.13, 2.43)	1.89 (1.57, 2.29)
Late follow-up period (10 – 14 years)	2.70 (2.60, 2.80)	2.13 (2.06, 2.21)	1.81 (1.73, 1.89)	1.96 (1.85, 2.08)	2.01 (1.78, 2.27)	1.69 (1.42, 2.00)
Govt. Funded Drug (<.0001) ^a						
Coverage initial period 0 - 4 years	0.61 (0.59, 0.62)	0.77 (0.75, 0.79)	0.88 (0.84, 0.92)	0.64 (0.62, 0.65)	0.80 (0.78, 0.82)	1.13 (1.06, 1.19)
Mid follow-up period (5 – 9 years)	0.59 (0.56, 0.61)	0.71 (0.68, 0.74)	0.81 (0.77, 0.86)	0.60 (0.57, 0.62)	0.77 (0.75, 0.80)	1.09 (1.02, 1.15)
Late follow-up period (10 – 14 years)	0.68 (0.63, 0.72)	0.76 (0.72, 0.80)	0.87 (0.81, 0.93)	0.63 (0.59, 0.66)	0.85 (0.81, 0.88)	1.19 (1.11, 1.27)

*The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

** Adjusted for age at start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

*** Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at the start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, and the residuals of the first regression. The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

Models were analyzed using the Generalized Estimating Equations (GEE) model with logistic regression for the population.

^a p-value of interaction between immigrant status and age.

Appendix III.4: Trajectories of unadjusted and adjusted odds ratios of annual inpatient healthcare use between immigrants and non-immigrants, stratified by sex

Follow-up time groups	Males			Females		
	Unadjusted* ORs (95% CI)	Adjusted** ORs (95% CI)	Adjusted*** ORs (95% CI)	Unadjusted* ORs (95% CI)	Adjusted** ORs (95% CI)	Adjusted*** ORs (95% CI)
Baseline age 21 – 40 (>.0001) ^a						
Coverage initial period (0 - 4 years)	0.42 (0.40, 0.45)	0.54 (0.51, 0.56)	0.49 (0.45, 0.53)	1.27 (1.25, 1.29)	1.51 (1.48, 1.54)	
Mid follow-up period (5– 9 years)	0.44 (0.41, 0.47)	0.48 (0.44, 0.52)	0.44 (0.40, 0.49)	0.98 (0.96, 1.01)	0.99 (0.97, 1.02)	
Late follow-up period (10 – 14 years)	0.47 (0.44, 0.51)	0.46 (0.41, 0.52)	0.43 (0.38, 0.50)	0.73 (0.69, 0.77)	0.65 (0.61, 0.69)	
Baseline age 41 – 60 (0.004) ^a						
Coverage initial period (0 - 4 years)	0.36 (0.34, 0.38)	0.51 (0.48, 0.55)	0.34 (0.24, 0.49)	0.47 (0.44, 0.51)	0.67 (0.63, 0.70)	0.58 (0.52, 0.65)
Mid follow-up period (5 – 9 years)	0.34 (0.32, 0.38)	0.41 (0.35, 0.47)	0.28 (0.18, 0.43)	0.40 (0.38, 0.43)	0.48 (0.44, 0.56)	0.42 (0.37, 0.47)
Late follow-up period (10 – 14 years)	0.45 (0.39, 0.52)	0.42 (0.28, 0.61)	0.29 (0.15, 0.56)	0.44 (0.40, 0.48)	0.50 (0.45, 0.56)	0.44 (0.38, 0.52)

*The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

** Adjusted for age at start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW.

*** Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at the start of coverage, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, and urban/rural residence. The model incorporated the first-order autoregressive AR (1) within-subject correlation and IPCW. Models were analyzed using the Generalized Estimating Equations (GEE) model with a log-gamma distribution for the hurdle model.

^a p-value of interaction between immigrant status and sex.

Appendix III.5 Unadjusted and adjusted odds ratios of annual healthcare use between immigrants and non-immigrants by healthcare services over the last 10 years of life

Follow-up time	Unadjusted* ORs (95% CI)	Adjusted** ORs (95% CI)	Adjusted*** ORs (95% CI)
Physician care			
0 (Year of death)	0.43 (0.39, 0.47)	0.49 (0.43, 0.55)	0.53 (0.44, 0.65)
-1	0.49 (0.44, 0.53)	0.57 (0.50, 0.64)	0.73 (0.60, 0.88)
-2	0.47 (0.42, 0.51)	0.61 (0.54, 0.68)	0.80 (0.66, 0.96)
-3	0.50 (0.45, 0.55)	0.65 (0.58, 0.73)	0.85 (0.70, 1.03)
-4	0.51 (0.47, 0.56)	0.69 (0.62, 0.77)	0.78 (0.65, 0.93)
-5	0.52 (0.48, 0.58)	0.71 (0.64, 0.80)	0.81 (0.68, 0.97)
-6	0.52 (0.48, 0.58)	0.69 (0.61, 0.77)	0.85 (0.71, 1.01)
-7	0.55 (0.50, 0.61)	0.71 (0.63, 0.79)	0.82 (0.69, 0.97)
-8	0.58 (0.53, 0.64)	0.74 (0.65, 0.83)	0.84 (0.70, 1.00)
-9	0.63 (0.57, 0.70)	0.85 (0.75, 0.96)	1.04 (0.87, 1.25)
Inpatient Care			
0 (Year of death)	0.95 (0.89, 1.01)	1.15 (1.07, 1.24)	2.18 (1.92, 2.47)
-1	0.79 (0.73, 0.85)	0.90 (0.82, 0.98)	1.28 (1.09, 1.51)
-2	0.70 (0.64, 0.76)	0.83 (0.76, 0.92)	1.03 (0.86, 1.23)
-3	0.61 (0.55, 0.67)	0.71 (0.64, 0.79)	0.85 (0.70, 1.04)
-4	0.51 (0.46, 0.57)	0.63 (0.56, 0.71)	0.68 (0.55, 0.83)
-5	0.51 (0.46, 0.58)	0.66 (0.59, 0.75)	0.67 (0.53, 0.84)
-6	0.53 (0.47, 0.60)	0.68 (0.60, 0.77)	0.78 (0.63, 0.97)
-7	0.48 (0.42, 0.56)	0.61 (0.53, 0.70)	0.76 (0.61, 0.96)
-8	0.55 (0.47, 0.63)	0.70 (0.60, 0.81)	0.73 (0.57, 0.92)
-9	0.58 (0.50, 0.67)	0.74 (0.63, 0.86)	0.93 (0.73, 1.18)
Day Surgery			
0 (Year of death)	0.88 (0.80, 0.97)	0.88 (0.80, 0.97)	0.53 (0.44, 0.63)
-1	0.91 (0.83, 0.99)	0.93 (0.85, 1.02)	0.75 (0.64, 0.88)
-2	0.80 (0.72, 0.88)	0.85 (0.77, 0.93)	0.74 (0.63, 0.87)
-3	0.79 (0.71, 0.87)	0.83 (0.75, 0.92)	0.79 (0.67, 0.94)
-4	0.79 (0.71, 0.88)	0.85 (0.77, 0.94)	0.86 (0.72, 1.03)
-5	0.69 (0.62, 0.77)	0.76 (0.68, 0.85)	0.78 (0.64, 0.94)
-6	0.64 (0.57, 0.72)	0.68 (0.61, 0.77)	0.78 (0.65, 0.94)
-7	0.55 (0.48, 0.63)	0.59 (0.52, 0.68)	0.68 (0.55, 0.83)
-8	0.57 (0.49, 0.65)	0.60 (0.53, 0.69)	0.65 (0.52, 0.80)
-9	0.63 (0.55, 0.72)	0.67 (0.58, 0.77)	0.75 (0.62, 0.91)
Emergency Department Care			
0 (Year of death)	2.1 (2.0, 2.3)	1.91 (1.79, 2.05)	1.92 (1.79, 2.06)
-1	1.13 (0.99, 1.30)	0.93 (0.81, 1.07)	0.92 (0.80, 1.06)
-2	1.27 (1.03, 1.56)	1.07 (0.87, 1.33)	1.08 (0.87, 1.33)
-3	1.18 (0.91, 1.53)	1.00 (0.76, 1.31)	1.01 (0.78, 1.31)
-4	0.77 (0.52, 1.11)	0.68 (0.46, 0.99)	0.67 (0.46, 0.98)
-5	0.64 (0.40, 1.04)	0.58 (0.36, 0.94)	0.58 (0.36, 0.94)

-6	0.52 (0.28, 0.98)	0.46 (0.25, 0.86)	0.46 (0.24, 0.86)
-7	0.95 (0.57, 1.58)	0.83 (0.50, 1.39)	0.83 (0.50, 1.40)
-8	0.87 (0.47, 1.62)	0.75 (0.40, 1.40)	0.75 (0.40, 1.41)
-9	0.40 (0.12, 1.23)	0.34 (0.11, 1.06)	0.34 (0.11, 1.06)
Government Funded Drug			
0 (Year of death)	0.97 (0.91, 1.03)	1.39 (1.30, 1.49)	
-1	0.91 (0.86, 0.97)	1.31 (1.22, 1.39)	
-2	0.83 (0.78, 0.88)	1.19 (1.12, 1.27)	
-3	0.80 (0.75, 0.85)	1.15 (1.07, 1.22)	
-4	0.78 (0.73, 0.83)	1.13 (1.05, 1.21)	
-5	0.71 (0.66, 0.76)	1.02 (0.96, 1.09)	
-6	0.73 (0.68, 0.78)	1.06 (0.98, 1.13)	
-7	0.75 (0.69, 0.80)	1.07 (0.99, 1.15)	
-8	0.73 (0.68, 0.79)	1.04 (0.97, 1.12)	
-9	0.72 (0.67, 0.78)	1.00 (0.92, 1.08)	

*The model incorporated the first-order autoregressive AR (1) within-subject correlation.

** Adjusted for age at year of death, squared age at year of death, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index and urban/rural residence. The models incorporated the first-order autoregressive AR (1) within-subject correlation.

*** Model was fitted using 2SRI. In the first stage, the outcome is the comorbidity index, and the predictors are region of origin, economic immigrant(yes/no) and refugee (yes/no). The second stage was adjusted for age at year of death, squared age at year of death, marital status, sex, employment/income assistance, rent assistance, Charlson comorbidity index, urban/rural residence, and residuals of the first regression. The model incorporated a first-order autoregressive (AR1) within-subject correlation.

Models were analyzed using the Generalized Estimating Equations (GEE) model with a log-gamma distribution for the population.

CHAPTER 4

TRAJECTORIES OF HEALTHCARE COSTS BEFORE AND AFTER CANCER DIAGNOSIS AMONG IMMIGRANTS AND NON- IMMIGRANTS IN MANITOBA

ABSTRACT

Background: Cancer is a major contributor to mortality in Canada. Immigrants arrive with generally better health in the host country, but that advantage erodes over time, as they face adaptation challenges resulting in lower routine health care use and higher end-of-life health care. Consequently, healthcare cost patterns before and after a cancer diagnosis may vary by immigration status.

Objectives: This study compared the healthcare costs of immigrants and non-immigrants for pre-and-post cancer diagnoses. Also, it compared these differences by sex and among immigrants by years since immigration.

Methodology: The matched-cohort study utilized 16 databases linked at the individual level encompassing immigration records, cancer diagnoses and treatments, medical claims, hospital abstracts, drug prescriptions, emergency department visits, home care, long-term care, vital statistics, mortality data, as well as housing and employment/income assistance information for individuals diagnosed newly with cancer between April 1995 and March 30, 2023. The study employed a two-part hurdle model: the first part used a logit model to determine whether an individual incurred any annual healthcare costs, while the second part used generalized estimating equations (GEE) with a log link and a gamma distribution.

Results: The average annual healthcare costs for immigrants (N=4288) and non-immigrants (N=12864) were CA\$8,550 and CA\$8,678, respectively. Immigrants had lower average annual healthcare costs (Adjusted mean difference [Amd] = CA\$-801; 95% CI: -1070, -505), inpatient care costs (Amd = CA\$-349; 95% CI: -496, -155), day surgery costs (Amd = CA\$-46; 95% CI: -68, -20), physician care costs (Amd = CA\$-100; 95% CI: -143, -57) than non-immigrants in the year preceding cancer diagnoses. Conversely, immigrants incurred higher healthcare costs during the diagnosis year (Amd: CA\$ 645; 95% CI: 114, 1203), inpatient care costs (Amd = CA\$474; 95% CI: 85, 906), and day surgery costs (Amd = CA\$65; 95% CI: 20, 113) compared to non-immigrants. Immigrants had lower odds of being admitted to an inpatient hospital (adjusted Odds Ratio [aOR] = 0.74; 95% CI: 0.64, 0.87), undergoing day surgery (aOR = 0.76; 95% CI: 0.67, 0.85), and visiting physicians (aOR = 0.80; 95% CI: 0.69, 0.92) in the year preceding cancer diagnosis. Conversely, immigrants had higher odds of visiting the ED (aOR = 1.40; 95% CI: 1.23, 1.59) and of being admitted to inpatient hospital care (aOR = 1.15; 95% CI: 1.05, 1.26) in the year of diagnosis.

Among immigrant subgroups, those living in Canada for a shorter duration had less healthcare use and lower annual healthcare costs before a cancer diagnosis. Specifically, immigrants who had resided in Canada for 10 years or less had annual costs of CA-\$1579 (95% CI: -2097, -952) lower before cancer diagnosis than those who had lived there for over 20 years. In addition, recently arrived immigrants were less likely to visit a physician (aOR=0.55; 95% CI: 0.40, 0.75) before cancer diagnoses and more likely to visit the ED (aOR=1.54; 95% CI: 1.18, 2.02; aOR=2.08; 95% CI: 1.59, 2.72) and be admitted to inpatient hospital care (aOR=1.64; 95%

CI: 1.32, 2.04) in the year of cancer diagnosis compared to those who had lived for over 20 years.

Conclusion: The patterns of healthcare costs before and after a cancer diagnosis revealed notable differences between immigrants and non-immigrants. Before diagnosis, immigrants were less likely to be admitted to a hospital, undergo day surgery, or visit a physician, and therefore incurred lower inpatient, day-surgery, and physician care costs; however, these trends for inpatient care, day surgery, and physician care reversed during the year of diagnosis.

Additionally, variability in healthcare cost patterns was observed among immigrants, depending on how long they resided in Canada. This disparity might result from limited healthcare access or delays experienced by immigrants during their integration prior to diagnosis, as well as the impact of their pre-immigration status.

4.1 Introduction

The Healthy Migrant Effect (HME) indicates that new immigrants possess better health at the time of landing compared to the Canadian-born population. Canada's immigration policies tend to favour the selection of immigrants with better health compared to the Canadian-born population (Lu and Ng, 2019; Lu et al., 2017; Wanigaratne et al., 2015; Ng, 2011). Such a trend of immigrants' health advantage tends to decline over time, primarily because of a new lifestyle in the host country, coupled with stress and difficulties of integrating into the new society (McDonald and Kennedy, 2005; Ng et al., 2011; Vang et al., 2015; Cheung et al., 2016; Holz, 2022).

Recent studies on the HIE in Canada identified that immigrants had lower mortality risk and fewer chronic conditions than Canadian-born individuals (Cheung et al., 2016; Debbarman et al., 2023; Lu and Ng, 2019). However, mortality risks vary among immigrants based on their immigration characteristics (Debbarman et al., 2023) and the duration of their stay in Canada (Cheung et al., 2016). The mortality advantage of immigrants among cancer patients diminishes over time, and the mortality risk of immigrants converges to the Canadian-born cancer patients with time in Ontario (Cheung et al., 2016). A study using data from the 1991 Canadian census, combined with 13 consecutive years of cancer and mortality information from administrative datasets, revealed that recent immigrants to Canada are less likely to receive a cancer diagnosis compared to non-immigrants. The reason for this finding is unclear; it might support the Health Immigration Effect (HIE) or indicate the impact of delayed routine care. Additionally, the study revealed that the health advantage of having fewer cancer diagnoses among immigrants diminishes the longer they stay in Canada, eventually converging with the rates found in the Canadian-born population (McDonald et al., 2017).

4.1.1 Impact of Immigration Policy on Immigrant Health

In Canada, most immigrants are economic immigrants who are selected through a careful selection process that evaluates their skills and the country's labour market requirements (Ferrer et al., 2014). Immigrants applying for permanent residency in Canada are required to complete a medical examination. Applicants may be inadmissible based on their health conditions if those conditions would place excessive demands on healthcare (more than \$27,162 annually based on the 2025 cost threshold) or social services, danger to public safety, and danger to public health, except for refugees and protected persons under subsection 38(2) of *the Immigration and Refugee Protection Act*. According to the Immigration, Refugees and Citizenship Canada (IRCC) report, approximately 0.3% of permanent resident applications were deemed inadmissible to Canada each year due to health reasons (IRCC, 2015).

4.1.2 Eligibility for Manitoba Healthcare Coverage and healthcare use of new Manitobans

Permanent residents are eligible to apply for Manitoba healthcare coverage from the date they arrive in Manitoba. Refugee claimants awaiting a decision who hold a work permit can apply from the date their work permit was issued. The refugee claimants who have not received a work permit may be eligible for healthcare coverage under the Interim Federal Health Program. Refugee claimants who receive a positive decision on their claim can apply for Manitoba Healthcare Coverage from the date of that decision. Additionally, temporary residents with a work permit can apply for Manitoba Healthcare Coverage from the date their work permit was issued, even before obtaining permanent resident status. All Manitoba Healthcare Coverage applicants must provide proof of their residence in Manitoba. As of February 11, 2025, the processing time for the Manitoba Health coverage application is four weeks (Manitoba Health, 2024). In addition, Immigration policy plays an important role in shaping cancer risk patterns

among populations. Immigration policies with medical admissibility tests tend to favour the positive selection of immigrants who are in better health compared to the Canadian-born population (Lu and Ng., 2019; Lu et al., 2017; Wanigaratne et al., 2015; Ng, 2011).

To investigate the healthcare utilization patterns among new Manitobans, a study matched individuals born in Manitoba or those who resided in Manitoba prior to the establishment of the Manitoba health coverage registry in 1970 with international migrants born outside Canada. The matching criteria included the same birth year, sex, and initial place of residence in Manitoba. This study revealed that approximately 75% of immigrants in that matched cohort accessed healthcare services within their first year of obtaining provincial coverage (Urquia et al., 2020). However, the ambulatory visit rates and Hospitalization rates at 1 year and 5 years from the start of healthcare coverage were found to be lower for matched immigrants compared to non-immigrants, defined as people who were born in Manitoba or lived in Manitoba before the establishment of the Manitoba health coverage registry in 1970 (Urquia et al., 2020).

4.1.3 Immigration population growth, composition, and mortality

The immigrant population in Canada has been consistently growing over the years. The 2011 census indicated that immigrants comprised 20.6% of the total Canadian population, a figure that rose to 23% by the 2021 census (Statistics Canada, 2024). Projections suggest that this trend will continue, with the immigrant population expected to account for 31.8% of the total Canadian population by 2041 (Statistics Canada, 2022).

According to the Permanent Resident Database, 75% of immigrants who arrived in Manitoba between 1985 and 2017 settled in Canada after 1999. A significant portion of them, 62%, originated from Asia. Upon arrival, the largest demographic was young adults aged 25-44,

who made up 47% of new immigrants, alongside children and youth under 15, who represented 26%. The matched study conducted by Urquia et al. (2020) found that the 5-year and 10-year crude mortality rates from the start of healthcare coverage for immigrants were significantly lower than those of non-immigrants, irrespective of the age groups.

4.1.4 Cancer incidence and mortality trends in Canada

In the 21st century, cancer will remain the leading cause of death (25% of deaths in Canada) and a significant obstacle to enhancing life expectancy (Canadian Cancer Statistics, 2023). The lives of cancer patients are significantly impacted by the disease, and it is projected that two out of five Canadians will be diagnosed with cancer at some point in their lives. Among cancers diagnosed in Canada in 2023, 65% were diagnosed at or after 65 years of age (Statistics Canada, 2022; Canadian Cancer Statistics, 2023).

It is projected that while Age-Standardized Cancer Incidence Rates (ASIRs) and Age-Standardized Mortality Rates (ASMRs) for some leading cancers, such as colorectal, lung, and prostate cancer, will continue to decline, the rates for others, including kidney cancer, liver cancer, intrahepatic bile duct cancer, melanoma, and non-Hodgkin lymphoma, are projected to increase (Brenner et al., 2024). The Canadian Centre of Cancer Information (CCCI) data from 2012 to 2019, excluding Quebec, indicated a declining trend in the ASIRs for all combined primary cancer sites. However, the ASIRs for several specific cancer sites, other female genital systems, myeloma, acute lymphocytic leukemia, and Hodgkin lymphoma revealed a minor increase (Statistics Canada, 2023). The CCCI data indicated a slight decline in the ASIRs for all combined primary cancer sites from 2012 to 2021 in Manitoba, except for prostate cancer (Statistics Canada, 2023). In Manitoba, similar trends are observed for liver and intrahepatic bile ducts, corpus uteri, uterus, and unspecified parts (Statistics Canada, 2023).

Utilizing the Onco Sim model, a web-based simulation tool that forecasts health and economic outcomes for cancer patients based on real data, expert opinions, and published literature, Runa et al. (2023) have projected that the overall incidence of cancer and related deaths in Canada will rise by 40% and 44%, respectively, from 2020 to 2040. The expected increase is largely due to an aging population and growth in population size. While the ASIRs and mortality rates were projected to remain relatively stable, there would be a slight rise in the ASIR and a slight decline in ASMRs over time (Runa et al., 2023).

4.1.5 Differences in overall and site-specific cancer incidence between immigrants and non-immigrants

Disparities in cancer incidence rates have been noted between immigrants and non-immigrants (Cheung et al., 2016; Malagon et al., 2024). A study analyzing members of the 2006 and 2011 Canadian Census Health and Environment cohorts estimated the person-time of respondents from the year they completed their survey (either 2006 or 2011) until their year of death or December 31, 2015. The study found that immigrants exhibited a significantly lower rate of age-standardized overall cancer incidence compared to their Canadian-born counterparts (Malagon et al., 2023). For most cancer types, Canadian-born individuals from diverse racial backgrounds showed incidence rates that were more similar to those of Canadian-born White individuals than to foreign-born members of the same racial groups. This indicated a trend of convergence between Canadian-born members of various racial groups and Canadian-born Caucasian individuals, with the notable exceptions of thyroid, stomach, and cervical cancers, as well as multiple myeloma (Malagon et al., 2023).

Furthermore, a study examining cancer diagnoses based on immigration status over a 13-year period revealed that recently arrived immigrants exhibited a significantly lower incidence

rate of all cancers, including the most common types, compared to their Canadian-born counterparts (McDonald et al., 2017). Additionally, the difference in cancer diagnosis rates between immigrants and non-immigrants declined with longer durations of stay for immigrants in Canada, eventually reaching the levels of non-immigrants (McDonald et al., 2017).

4.1.6 Cancer outcomes of immigrants and non-immigrants

Contemporary studies revealed notable variations in cancer outcomes between immigrants and non-immigrants. Immigrants had a slightly higher likelihood of being diagnosed at an advanced stage compared to non-immigrants (Parvez et al., 2023; Lofters et al., 2021). Research examining prostate cancer patients revealed differences in the stage of diagnosis among immigrants from various regions compared to non-immigrants, but both unadjusted and adjusted analyses of five-year survival rates indicated that immigrants exhibited higher survival rates than their non-immigrant counterparts in Canada (Lofters et al., 2024).

Research that compared immigrants and non-immigrants diagnosed with cancer to matched controls revealed that immigrants with cancer had higher age-standardized 5-year relative survival rates for all cancers and specific cancer types compared to non-immigrants with cancer, with the exceptions of melanoma and uterine (female) cancer cases (Malagon et al., 2024). Research examining linked administrative datasets of individuals diagnosed with lung, colorectal, prostate, breast, head and neck, and hematologic malignancies in Ontario from 2000 to 2012 identified that both recent immigrants (0 to 10 years in Canada) and non-recent immigrants (11 to 25 years in Canada) experienced lower risks of all-cause and cancer-related mortality compared to non-immigrants (Cheung et al., 2017).

Research utilizing the 2006 Canadian Census Health and Environment cohort, linked with the Canadian Vital Statistics and the Canadian Cancer Registry from 2006 to 2016,

indicated that immigrants exhibited lower cancer mortality rates compared to non-immigrants within the same ethnic groups (Hwee and Bougie, 2021). Ethnic groups with a significant proportion of Canada's total immigrant population, including South Asian, East Asian, African, West Central Asian, Middle Eastern, as well as Latin, Central and South American, and Caribbean non-immigrants showed considerably higher cancer mortality rates than their immigrant counterparts, irrespective of sex (Hwee and Bougie, 2021).

4.1.7 The number of years since immigration and cancer incidence and outcomes

The duration of an immigrant's stay in the host country significantly impacts cancer incidence rates and outcomes. A population-based study found that the risk of lifestyle-related cancers escalated with the length of residence in the host nation (Lamminmäki et al., 2023). A significant correlation between the length of stay of immigrants and an elevated risk of colorectal and breast cancers with an obvious 7% increase for every additional 5 years spent in Ontario, Canada (Shuldiner et al., 2018). Research examining a continuous 13-year observation period of administrative datasets ascertained that the effect of healthy immigration diminished over the years following immigration as it related to cancer diagnosis (McDonald et al., 2017).

4.1.8 Determinants of cancer risks in immigrants and non-immigrants

Approximately 33% to 37% cancer cases could be attributed to external risk factors like behavioural and lifestyle choices, environmental conditions, socioeconomic status, and vulnerability to infections (Poirier et al., 2019; Brown et al., 2018). The lifestyle factors include diet, smoking, obesity, and occupational exposures, which are associated with various cancer types, including colorectal, uterine (corpus), breast, kidney and renal pelvis, prostate, leukemia, and lymphoma (Thun et al., 2018; Poirier et al., 2019; Malagon et al., 2023). Furthermore, tobacco and alcohol consumption, and early life experiences such as smoking, alcohol

consumption, and human papillomavirus infection prior to immigration, are closely linked to cancers of the esophagus, head and neck, cervix, lung, and bronchus. Nevertheless, immigrants exhibit lower incidence rates for these types of cancer (Thun et al., 2018; Poirier et al., 2019; Gormley, et al., 2022; Malagon et al., 2023).

The process of positive selection considers applicants' overall health, socioeconomic status, and educational achievements. This careful consideration allows for the identification of individuals who are less prone to engage in unhealthy behaviours, such as heavy drinking and smoking, and a lower rate of obesity and fewer chronic conditions (Lu and Ng., 2019). As a result, these selected individuals exhibit a significantly lower likelihood of developing cancers (Lu and Ng., 2019; Agic et al., 2016). Cultural differences in smoking behaviours and the consumption of fruits and vegetables among various ethnic groups play a significant role in influencing cancer risk. These lifestyle choices are not just variations; they are important factors that contribute to differing levels of cancer susceptibility across immigrants and Canadian-born populations (Smith-Warner et al., 2003; Pérez-Stable et al., 1998; Caraballo et al., 1998).

Numerous studies examining geographical disparities in birth regions emphasized differences in cancer incidence, survival rates, and mortality (Shuldiner et al., 2018; Dasgupta et al., 2019). Research conducted in Ontario revealed that adjusted age-standardized incidence rates for colorectal and breast cancers were lowest among immigrants originating from South Asia compared to non-immigrants, while immigrants from Central Asia and Europe had the highest additional risk for colorectal cancer, and immigrants from the Middle East and North Africa faced the highest risks of breast cancer (Shuldiner et al., 2018).

In a similar vein, a British Columbia-based study examined variations in age-standardized breast cancer incidence rate ratios between immigrants and non-immigrants by

county and region of birth, finding that women from South and East Asia had lower ratios, whereas women from Western Europe had higher ratios (Woods et al., 2019). However, an earlier study based on birth regions in Ontario found no significant differences in cancer-related mortality between immigrants from African, European, South Asian, and Caribbean countries and non-immigrants (Cheung et al., 2017).

Although Middle Eastern immigrant women with cancer reported satisfaction with the quality of healthcare received, they faced delays in accessing services and had unmet needs. The experiences of these delays varied across different immigrant categories: refugees and individuals in the family class reported fewer challenges in obtaining healthcare, while immigrant women from the economic class faced difficulties stemming from a lack of local support and limited awareness of Canadian healthcare policies (Alsayheen et al., 2023).

Additionally, factors including stress, lifestyle and diet change, language barrier, low socio-economic status, educational attainment, cultural background, and lack of social inclusion contribute to the declining health status of immigrants with the duration of stay (Steele et al., 2002; Subedi & Rosenberg, 2014; Patel et al., 2019; Niraula et al., 2023).

4.1.9 Cancer incidence and outcomes among immigrants and non-immigrants by sex

A study that examined recently arrived immigrants noted the odds of being diagnosed with any cancer for immigrant males were 0.517 compared to non-immigrant males, whereas immigrant females had odds of 0.638 compared to non-immigrant females (McDonald et al., 2017). Analysis of premature cancer mortality rates between immigrants and non-immigrants by sex in Spain revealed that immigrants exhibited lower rates than their non-immigrant counterparts, with disparity more pronounced among men than women (Grande et al., 2023). Among immigrant women, the number of years since immigration did not seem to impact their

health significantly, which might be attributed to relatively healthier integration into the host country than male immigrants (Grande et al., 2023). However, a population study utilizing the registries of Nordic countries revealed that a longer duration of residence in the host country significantly raised the incidence and mortality rates of breast and lung cancers among non-Western immigrant women (Lamminmaki et al., 2023).

4.1.10 Research gaps

The recent research on immigrant health related to cancer yielded several important questions:

First, how do the patterns of healthcare utilization and costs change over time after a cancer diagnosis for immigrants compared to non-immigrants, considering treatment prior to diagnosis? As previously noted, immigrants tend to experience better survival rates and lower mortality rates than their non-immigrant counterparts (Cheung et al., 2017; Hwee and Bougie, 2021). However, the initial advantage of lower cancer diagnosis rates among immigrants diminishes over time (McDonald et al., 2017; Steele et al., 2002; Subedi & Rosenberg, 2014; Patel et al., 2019; Niraula et al., 2023).

Analyzing patterns of healthcare utilization and the overall annual healthcare costs for both immigrants and non-immigrants over time following a cancer diagnosis would provide valuable insights into how immigration status and years since migration in Manitoba influence the decision of healthcare utilization. Although Cronin et al. (2016) estimated the long-term healthcare costs for cancer patients in Australia, comparisons between costs incurred for immigrants and non-immigrants were missing. Fuller-Thomson et al. (2011) and Newbold (2009) investigated the impact of years since immigration on health status using a longitudinal

survey of immigrants in Canada, focusing solely on immigrants' self-assessed health status for 4 years following their arrival.

Utilizing a more comprehensive dataset with information on individuals diagnosed with cancer, overall healthcare utilization and costs, as well as socio-demographic and economic status, would provide deeper insights into the trends in healthcare utilization and expenses for both immigrants and non-immigrants before and after a cancer diagnosis. Importantly, immigrant cancer patients are more likely to receive aggressive treatment near the end-of-life (Chu et al., 2021; Tergas et al., 2022; Yarnell et al., 2017; Shen et al., 2019; Quach et al., 2021). A study analyzing healthcare use and overall annual costs before and after cancer diagnosis would help assess whether healthcare decisions made during the initial stages of living in Canada differ. Positive selection of immigration (based on immigration categories) and different geographic and cultural backgrounds deserve attention as they relate to healthcare utilization after a cancer diagnosis compared to non-immigrants.

Second, do healthcare utilization and costs differ over time after diagnosis between male and female immigrant and non-immigrant cancer patients, considering pre-diagnosis treatment? The risk of a cancer diagnosis for male immigrants aligns more rapidly with that of Canadian-born individuals as the number of years since immigration increases, in contrast to female immigrants (McDonald et al., 2017). Research on the Spanish population revealed that the disparity in premature cancer mortality was greater between immigrant men compared to native-born men, while the difference was less pronounced between immigrant women and native women and also, among men from European and Maghreb regions, as well as Latin American men and women, who displayed a lower risk of premature cancer mortality compared to their Spanish-born counterparts (Grande et al., 2023).

There is limited information regarding the differences in healthcare utilization and costs between immigrant and non-immigrant cancer patients. This research gap limits our understanding of healthcare utilization patterns and costs for both immigrant and Canadian-born patients with cancer. As overall and per capita health expenditures in Canada increase due to population growth driven by immigration and an aging demographic, it is crucial to examine how healthcare utilization and costs differ among various groups diagnosed with cancer.

4.2 Objectives

1. To analyze the healthcare costs of immigrants versus non-immigrants in Manitoba who are diagnosed with cancer over extended periods. The main objective is to estimate the pattern of total direct healthcare costs of immigrants and non-immigrants pre- and post-cancer diagnosis.
2. To examine the trends in healthcare use and costs pre- and post-cancer diagnosis by healthcare services between immigrants and non-immigrants.
3. To examine the differences in healthcare use and cost patterns over time among cancer patients before and after diagnosis between immigrants and non-immigrants by sex, and
4. To examine the pattern of healthcare use and costs pre- and post-cancer diagnosis among immigrants by years since immigration.

Based on the literature, it can be expected that:

Hypothesis 1: The average annual healthcare costs of immigrants are lower than those of non-immigrants before the cancer diagnosis.

Rationale: Canadian immigration policy, along with factors such as socioeconomic status, education, a healthy diet and lifestyle, and a lower prevalence of chronic conditions, plays a

significant role in the process of positive selection in immigration. As a result, immigrants upon arrival have better health than the non-immigrant population, a phenomenon referred to as the Healthy Immigrant Effect (HIE) (Lu & Ng, 2019; Agic et al., 2016; Lu et al., 2017; Wanigaratne et al., 2015; Ng, 2011).

In addition, upon arrival, immigrants often encounter challenges in navigating the new healthcare system due to their experiences in different healthcare systems, language barriers, cultural differences, and structural obstacles, including a lack of childcare during medical appointments, and limited transportation options, all of which complicate immigrants access to health services upon arrival (Salami et al., 2020; Tsai & Ghahari, 2023; Pandey et al., 2022; Dastjerdi, 2012; Asanin, 2008).

Hypothesis 2: The average annual healthcare costs of immigrants are higher than those of non-immigrants at the diagnosis year and after the cancer diagnosis year.

Rationale: Present research indicates that cancer patients who are immigrants in Canada tend to be diagnosed at a later stage than their non-immigrant counterparts (Parvez et al., 2023; Lofters et al., 2021). This delayed diagnosis may lead to higher healthcare costs for immigrants compared to non-immigrants following a cancer diagnosis.

Hypothesis 3: The average annual healthcare costs vary among female immigrants and female non-immigrants, and male immigrants and non-immigrants, both before and after a cancer diagnosis.

Rationale: Immigrant women are less likely to be diagnosed with early-stage breast cancer compared to Canadian-born women. However, this difference varies by the region of origin of the immigrant women (Iqbal et al., 2017; Lofter et al., 2019). A study conducted among male residents of Ontario diagnosed with prostate cancer revealed that men from East Africa,

West Africa, and the Caribbean were more likely to receive an early diagnosis. In contrast, South Asian men were significantly less likely to be diagnosed at an early stage compared to non-immigrants (Lofters et al., 2024).

4.3 Methods

4.3.1 Data sources

This matched study used administrative datasets. Immigration information, such as admission categories, landing year, and region of origin, were obtained from the Immigration, Refugees and Citizenship Canada (IRCC) permanent residents' dataset. IRCC permanent residents' database, the Manitoba Health Insurance registry, Manitoba Cancer registry, medical claims, Drug Program Information Network (DPIN), hospital abstracts (DAD/MADE), Vital Statistics Mortality, Social Housing-Rented Aid (Manitoba Shelter Benefit), Emergency Department Information System (EDIS), Emergency - Admission, Discharge and Transfer (ADT) and E-Triage, Home Care Assessment, Home Care Utilization, Home Care – PROCURA, Long Term Care Assessment, Long Term Care Utilization, and Social Allowances Management Information Network (SAMIN) datasets were linked using the scrambled Personal Health Identification Number (PHIN). The study also classified all individuals into five neighbourhood income quintiles based on the average household income of the place of residence from 1991, 1996, 2001, 2006, 2011, 2016, and 2021 Canadian Censuses at the respective calendar year.

4.3.2 Cohorts and matching criteria

The first year of immigrants' Manitoba health coverage was excluded to allow them to register for provincial healthcare and establish a minimum history of eligibility for a cancer diagnosis. Immigrants diagnosed with cancer during their first year of coverage were excluded

from the cohorts. This is because new immigrants typically had to wait a few months to receive their health coverage card, even though they were eligible to apply for Manitoba health coverage immediately upon arrival. The cohort of cancer patients consisted of individuals who were newly diagnosed with cancer between April 1995 and March 30, 2022, and had at least one year of healthcare costs recorded before and after their diagnosis. The cohort follows immigrants either from two years prior to their cancer diagnosis or from the start of their healthcare coverage in Manitoba, whichever occurs first.

This monitoring continued up to three years after the time of diagnosis for the alive, or until the year of cancellation for those who passed away or left the province. For non-immigrants, the start time was the same as that of the matched immigrant, and they were followed until three years after the time of diagnosis for those who are alive or until the year of cancellation for those who died or left the province. Individuals who did not have at least 1 year of healthcare costs recorded before and after their diagnosis, or those who were temporary residents, were excluded.

In the cohort, the immigrants were matched with the non-immigrants at a ratio of 1:3 by time of diagnosis, sex, age, and region of residence (Urban/Rural) at the time of cancer diagnosis. This research considered the time of diagnosis with a flexible window of plus or minus three months (within six months), and the age at the time of cancer diagnosis with a flexible window of plus or minus five years (within ten years). To examine the annual healthcare cost differences before and after a cancer diagnosis among international immigrants based on their immigration characteristics, there was no need for matching since all immigrant cancer patients were included in the study population.

4.3.3 Variable definitions

Outcome variable: Annual healthcare costs

The annual total direct healthcare cost for individuals was used as the outcome variable of this study. As the study used annual data, it accounts for the timing of initiation and cancellation of healthcare coverage within the year. For that reason, the study annualized shorter-term healthcare cost records from the first and last follow-ups. This was annualized by multiplying the short-period costs by the annualization factor. The formula used for this factor is $(N/365) \times \text{CA\$}$, where N represents the number of days within the relevant year during which an individual's Manitoba health insurance coverage was active, and CA\$ denotes the Canadian dollar amount spent on healthcare during that period. The study restricts the factor to a maximum value of 12.

For instance, if an individual's follow-up began on October 25, 2012, the annualization of healthcare costs for that year would involve multiplying the healthcare costs by $(65/365)$, reflecting the days of active coverage. The same formula applied in cases of healthcare coverage cancellation due to death or outmigration during a portion of the year. The annual cost was converted to the 2022 Canadian dollar using the Consumer Price Index (CPI). The total direct cost of this study was the sum of the costs incurred for physician consultation, inpatient hospitals, day surgery, emergency department, long-term care, home care, and drug. The outcome variables for analyzing healthcare utilization included the number of visits to physicians, outpatient hospitals, emergency departments, prescriptions filled, days spent in the hospital, long-term care, and home care.

Comparison groups

This research compared two groups: immigrants whose coverage began between January 1, 1985, and March 2017, and non-immigrants who either resided in Manitoba prior to the establishment of the registry in 1970, were born in Manitoba after the registry's creation, or were born in other provinces across Canada. The immigrants were also categorized based on immigration characteristics, including economic immigrants (yes/no), refugees (yes/no), years since immigration, and region of birth.

Socio-demographic and other variables

Socio-demographic and economic characteristics for the analyses of these matched studies included age, sex, marital status, rural or urban residence, receipt of rental assistance, receipt of employment and income assistance, and neighbourhood income quantiles. The Charlson Comorbidity Index, cancer types, and stage of diagnosis were adjusted in the regression to control for health status and cancer information.

Time periods

The time periods were divided into three groups based on the timing of the observation relative to the diagnosis year. The groups were 1) pre-diagnosis years ($t < 0$), up to 2 years; 2) diagnosis year ($t = 0$); and 3) post-diagnosis years ($t > 0$), up to 2 years after the cancer diagnosis. Since the data were unbalanced due to variations in the start and end of Manitoba health insurance coverage for cancer patients, some observations were excluded after applying the criteria of at least 1 year of healthcare costs recorded before and after diagnosis.

4.3.4 Data analysis

The GLM with a gamma distribution and a log link appeared as a more robust model for right-skewed healthcare cost analysis (Malehi et al., 2015; Baldi, 2012). As the repeated observation of annual healthcare costs of an individual might be correlated (Liu et al., 2008), the generalized estimating equations (GEE) (Liang and Zeger, 1986) model with a log link and gamma distribution, and a first-order autoregressive correlation matrix provided consistent estimates of the regression parameter for repeated-measured annual healthcare costs (Kwon, 2017; Liang & Zeger, 1986; Rivera-Hernandez et al., 2022; Nabi et al., 2024). The study employed a two-part hurdle model, with the first part using a logit model to identify the presence of annual costs, and the second part using a GEE model (Buntin & Zaslavsky, 2004; Jennum et al., 2021) to handle skewed outcomes and zero costs.

The specification of the GEE is as follows:

$$\begin{aligned} \text{Healthcare Costs}_{ti} &= \beta_0 + \beta_1 \text{Immigrant}_i + \beta_2 (\text{Age at diagnosis time}_i) \\ &+ \beta_3 (\text{Age at diagnosis time}_i^2) + \sum_k \beta_{4k} \text{Time period}_k \\ &+ \sum_k \beta_{5k} (\text{Immigrant}_i * \text{Time period}_k) + \beta_6 \text{Cancer Stage at diagnosis}_i \\ &+ \beta_7 \text{Cancer Type}_i + \beta_8 \text{rent assistance}_{ti} \\ &+ \beta_9 \text{employment/income assistance}_{ti} + \beta_{10} \text{comorbidity index}_{ti} \\ &+ \beta_{11} \text{income quintile}_i + \varepsilon_{ti} \end{aligned}$$

4.3.4.1 Endogeneity due to omitted and selection bias

While economic and family-class immigrants were subject to medical screening during immigration, refugees and certain family-class immigrants were exempt from this requirement (Lu and Ng, 2019). Furthermore, the medical examination for those seeking permanent residence primarily assessed their potential impact on public health services and could result in inadmissibility due to excessive demand on these services (Lu and Ng, 2019). In addition, several infections might remain latent for many years and be detected in immigrants later (Barnett et al., 2023). Trauma-related mental health conditions might also be overlooked by the healthcare systems of the immigrant country of origin (Rosenthal, 2018). Moreover, conditions and circumstances surrounding migration, as well as epidemiological patterns of infectious diseases in the country of origin, might increase the risk of infectious diseases among immigrants in the host country (Barnett et al., 2023; Castelli and Sulis, 2017; Greenaway and Castelli, 2019; Schlagenhauf et al., 2018). Pre-immigration disease burden of immigrants remained unobserved and might be related to observed comorbidities, adding to omitted variable bias.

Economic immigrants in Canada are positively selected under the nation's immigration policy, which assesses individuals on human capital, age, and medical screening (Lu and Ng, 2019). In contrast, refugees are exempt from inadmissibility based on healthcare demand and health condition (Lu and Ng, 2019). They also face unique health challenges strongly shaped by the traumas and circumstances they experienced in their home countries (Muller et al., 2018). As a result, the healthy migrant effect (HME) was more pronounced among economic immigrants and significantly weaker among refugees, reflecting differences in selection criteria (Lu and Ng, 2019). Therefore, the selection process for immigrants might affect their observed comorbidities in the host country, potentially introducing selection bias.

As a result, the estimates might be biased due to endogeneity arising from the lack of pre-immigration information. Therefore, I used the two-stage residual inclusion model suggested by Terza et al. (2008), especially for non-linear regression analysis in health research, to address endogeneity. In the first stage, I estimated a negative binomial model with the outcome being the sum of the weighted Charlson Comorbidity Index scores for each year. The instruments were region of birth, economic immigrant (yes/no), and refugee (yes/no).

Instruments

Using instruments helped estimate the causal effect of an endogenous variable, specifically comorbidity, which correlates with unobserved variables and factors that contributed to selection bias, such as the disease burden before immigration. This method helped isolate the effect of comorbidity on the outcomes of interest, thereby improving the validity of the findings in the presence of potential confounding factors. The research employed the following instrumental variables to address endogeneity in comorbidity.

Region of Origin

The lack of financial support for healthcare costs in low- and middle-income countries is a substantial barrier to the use of healthcare services (Mills, 2014). Furthermore, the social, legal, economic, and cultural contexts of a country or region, as well as the characteristics shared by a community, significantly influence health outcomes (Zimmerman & Pronk, 2025; McKinlay, 1975; Achim et al., 2019).

Economic immigrants

Economic immigrants generally arrive in better health and with lower comorbidity, as they are selected on the basis of human capital criteria and undergo medical screening during the immigration process (Lu & Ng, 2019).

Refugee Status

Forced displacement and pre-migration disruptions in healthcare may be associated with health outcomes (Kumar et al., 2019; Kumar and Krasnik, 2020; Wanigaratne et al., 2018; Lange et al., 2024).

Exogeneity of instruments

Economic immigrant and refugee status are determined legally by immigration authorities based on the specific immigration programs under which individuals are selected. In contrast, a person's region of origin is established at birth. As fixed attributes, economic immigrant and refugee status are time-invariant and do not influence eligibility for services in the universal system, healthcare provider behaviour, or rules regarding treatment intensity. Consequently, these statuses might not directly affect healthcare utilization or costs. Instead, these instrumental variables affect healthcare utilization and costs indirectly by influencing comorbidity burden and health needs.

In the second stage, the research used a hurdle model to analyze annual healthcare costs. First, I applied pooled logistic regression to estimate the probability of incurring any costs in a given year ($\text{cost} > 0$). Next, I examined the positive costs with a gamma distribution and a log link, using Generalized Estimating Equations (GEE) with first-order autocorrelation to account for within-individual temporal correlation. In the GEE gamma model, where the outcome is annual healthcare costs, predictors included immigrant status (yes/no), age at cancer diagnosis,

time periods, the interaction between immigrant status and time periods, Charlson comorbidity index, income quantiles at diagnosis, EIA, rent assistance, marital status, status at end of follow-up, and the residuals from the first stage. If the residual term is significant, it indicates endogeneity and warrants its inclusion in the model. Additionally, I estimated the hazard odds ratio of death post-diagnosis, using GEE with a logit link (Masyn, 2013) to assess the variation in death risk between immigrants and non-immigrants during the initial years following diagnosis.

4.3.4.2 Inverse probability of censoring weights

Following the first year after a cancer diagnosis, the follow-up for some patients was lost due to death or outmigration. Since losses to follow-up can provide informative insights (Howe et al., 2016), the estimates derived from this data may be biased. To mitigate selection bias arising from these losses, the study employed inverse probability of censoring weights in its estimates to achieve unbiased results (Hernán et al., 2004; Hernán & Robins, 2016; Robin et al., 1995; Seamon and Copas, 2009).

The patient's information at the time of diagnosis—including age, comorbidities, neighbourhood income quantile, employment and income assistance, rent assistance, marital status, cancer stage, and cancer type along with a log of the previous year's healthcare costs, was used to estimate inverse probability weights. The outcome of the pooled logistic regression was survival: 1 if the individual was followed to the end of the study, and 0 if lost to follow-up due to cancellation of healthcare insurance coverage for death or outmigration. Age was included in the regression as both a linear and a quadratic term for survival.

4.4 Results

4.4.1 Descriptive Statistics

The data in Table 4.1 present the demographic details and annual HC costs of cancer patients newly diagnosed between 1995 and 2023. The total number of cancer patients in this matched cohort is 17152. Among them, 4288 were immigrants, and 12864 were non-immigrants. The study shows that 72% (N=12,326) were diagnosed between the ages of 41 and 70, and 56.7% were female. The table also indicates that 52% (N=2,986) were married or had a common-law partner (66% among immigrants and 47% among non-immigrants). Additionally, 86% of cancer patients lived in an urban area, and 39% (N=6,665) had three or more comorbidities (43% among immigrants and 38% among non-immigrants) at diagnosis.

The most common cancer site among Manitobans was non-melanoma skin cancer (28%), followed by breast (16%) and prostate (9%) cancers. The table also highlights differences in cancer sites between immigrants and non-immigrants. Among immigrants, the most common sites were breast (21%), followed by non-melanoma skin (16%) and prostate (11%). Conversely, among non-immigrants, non-melanoma skin cancer was most prevalent (32%), followed by breast (15%) and prostate (8%). The table also indicates that 76% of cancer patients in this study were alive at the end of the study, 22% had died, and 2% had moved out of Manitoba during the period.

Data contained in Table 4.1 shows that the annual per-person healthcare costs for newly diagnosed cancer patients in Manitoba from 1995 to 2023 averaged \$8,646 over 5 years pre- and post-diagnosis. In the year of diagnosis and the following year, healthcare costs increased to \$12,715 and \$11,167, respectively, compared to \$2,655 the year before diagnosis.

Table 4.1: Socio-demographic characteristics and average annual healthcare costs (AC) during January 1995–March 2023 among cancer patients

Characteristics	All N	%	AC (C\$)	Immigrants N	%	AC (C\$)	Non-Immigrants N	%	AC (C\$)
All*	17152	100	8646	4288	25.0	8550	12864	75.0	8678
Time Period									
Pre-diagnosis year 2 (t-2)	16868	19.97	2346	4153	19.76	1846	12715	20.04	2509
Pre-diagnosis year 1 (t-1)	17152	20.31	2655	4288	20.40	2198	12864	20.28	2808
Diagnosis year (t = 0)	17152	20.31	12715	4288	20.40	13541	12864	20.28	12439
Post-diagnosis year 1 (t+1)	17152	20.31	11167	4288	20.40	12493	12864	20.28	10724
Post-diagnosis year 2 (t+2)	16127	19.10	14599	4001	19.04	12743	12126	19.12	15211
Age at cancer diagnosis									
0 – 20	36	0.2	18406	9	0.2	15501	27	0.2	19309
21 – 30	271	1.6	7653	60	1.4	12035	211	1.6	6440
31 – 40	1507	8.8	7131	408	9.5	6992	1099	8.5	7183
41 - 50	3650	21.3	6628	980	22.9	7006	2670	20.8	6491
51 - 60	4919	28.7	7997	1235	28.8	8330	3684	28.6	7886
61 - 70	3757	21.9	10657	869	20.3	9567	2888	22.5	10983
71 - 80	2115	12.3	9630	506	11.8	9579	1609	12.5	9647
81 - above	897	5.2	12221	221	5.1	12039	676	5.3	12280
Sex									
Male	7424	43.3	9228	1856	43.3	9309	5568	43.3	9201
Female	9728	56.7	8203	2432	56.7	7974	7296	56.7	8279
Having Married/ Common-Law Partner at diagnosis									
Yes	8926	52.0	7456	2826	65.9	8219	6100	47.4	7105
No	8226	48.0	9933	1462	34.1	9186	6764	52.6	10094
Residence at diagnosis									
Rural Residence	2475	14.4	8971	611	14.3	8318	1864	14.5	9177
Urban Residence	14677	85.6	8627	3677	85.7	8714	11000	85.5	8599
Comorbidity Index at diagnosis									
0	1861	10.8	2145	319	7.4	2667	1542	12.0	1984
1 - 2	8626	50.3	6304	2137	49.8	6471	6489	50.4	6248
3	3225	18.8	13683	917	21.4	12085	2308	17.9	14279
4+	3440	20.1	27553	915	21.3	25637	2525	19.6	28192
Cancer Type									
Breast	2777	16.2	6836	900	21.0	5914	1877	14.6	7276
Colon	845	4.9	16543	215	5.0	11524	630	4.9	18262
Non-melanoma Skin	4832	28.2	3562	685	16.0	3220	4147	32.2	3618
Prostate	1508	8.8	5715	465	10.8	5247	1043	8.1	5923
Lung and bronchus	724	4.2	16903	216	5.1	17839	508	3.9	16505

Characteristics	All N	%	AC (C\$)	Immigrants N	%	AC (C\$)	Non-Immigrants N	%	AC (C\$)
Other	6466	37.7	12022	1807	42.1	11331	4659	36.2	12288
Cancer Diagnosis Stage									
Stage 0	23	0.1	5117	5	0.1	3126	18	0.1	5676
Stage 1	3889	22.7	7504	1051	24.5	5912	2838	22.1	8093
Stage 2	2330	13.6	8437	722	16.8	7479	1608	12.5	8864
Stage 3	1757	10.2	11650	513	12.0	10728	1244	9.7	12025
Stage 4	1157	6.8	20438	359	8.4	19427	798	6.2	20894
Unknown	7996	46.6	6959	1638	38.2	7736	6358	49.4	6760
Employment/ Income Assistance at diagnosis									
Yes	662	3.9	17886	171	4.0	17583	491	3.8	17987
No	16490	96.1	8297	4117	96.0	8209	12373	96.2	8327
Rent Assistance at diagnosis									
Yes	249	1.5	10766	153	3.6	9744	96	0.8	12498
No	16903	98.5	8617	4135	96.4	8508	12768	99.2	8652
Neighbourhood income level at diagnosis									
Quintile 1	2942	17.2	11465	956	22.3	8750	1986	15.4	12719
Quintile 2	3161	18.4	9143	888	20.7	8242	2273	17.7	9493
Quintile 3	3561	20.8	8331	799	18.6	9204	2762	21.5	8076
Quintile 4	3581	20.9	7878	859	20.0	8546	2722	21.2	7676
Quintile 5	3833	22.3	6959	777	18.1	8246	3056	23.8	6635
Quintile NF	74	0.4	12515	9	0.2	5839	65	0.5	18027
Status at last follow-up									
Alive	15775	92.0	6381	3913	91.3	6563	11864	92.2	6321
Dead	1260	7.3	40012	330	7.7	34636	930	7.2	41916
Outmigrant	117	0.7	4277	45	1.0	5492	70	0.5	3510
Immigration Characteristics of the Immigrant Population									
Refugee									
Yes				580	13.5	8945			
No				3708	86.5	8489			
Admission Category									
Economic Immigrant				2101	49.0	7898			
Family Class				1563	36.5	9290			
Refugee				580	13.5	8945			
Other Immigrant				44	1.0	8374			
Region of									

Characteristics	All			Immigrants			Non-Immigrants		
	N	%	AC (C\$)	N	%	AC (C\$)	N	%	AC (C\$)
Origin									
Southeast Asia				1460	34.0	8823			
South Asia				323	7.5	9810			
Rest of Asia				429	10.0	9013			
East Europe				622	14.5	9427			
Rest of Europe				530	12.4	6967			
North and East Africa				144	3.4	10960			
Sub-Saharan Africa				156	3.6	7261			
North America and Oceania				193	4.5	8792			
Latin America and Caribbean				431	10.1	6486			

* The first two rows represent row% and the remainder column %

Among immigrants and non-immigrants, the annual average healthcare costs in the year prior to diagnosis were \$2,198 and \$2,808, respectively. In the year of diagnosis, these costs rose to \$13,541 and \$12,439, and in the year following diagnosis, they were \$12,493 and \$10,724. Annual health care costs were substantially higher among older individuals (\$12,221 for those aged 81 years and above), those who were single (\$9,933), individuals with more comorbidities (\$27,553 for patients with four or more comorbidities), those diagnosed with lung cancer (\$16,903), and patients diagnosed at an advanced stage (\$20,438 for stage IV disease).

Data contained in Table 4.2 illustrates the patterns of healthcare service utilization among immigrants and non-immigrants before and after a cancer diagnosis. In the pre-diagnosis period, immigrants were less likely than non-immigrants to access most healthcare services, including inpatient care (5.29% versus 6.65%), day surgery (9.49% versus 11.82%), and physician services and tests (92.35% versus 93.71%). The exception was government-funded drug services, where utilization was higher among immigrants (19.22% versus 14.78%). Statistically significant differences were observed for these services ($p < 0.01$).

Table 4.2: Patterns of Healthcare Service Use Among Immigrants and Non-Immigrants Before and After Cancer Diagnosis.

Healthcare Services	Immigrants (%)	Non-immigrants (%)	Diff.	P-value of χ^2
Any HC service				
Pre-diagnosis year 2 (t-2)	89.86	92.21	-2.4	<.0001
Pre-diagnosis year 1 (t-1)	92.42	93.77	-1.7	0.002
Diagnosis year (t = 0)	99.98	99.94	0.04	0.34
Post-diagnosis year 1 (t+1)	97.76	98.52	-0.8	0.0007
Post-diagnosis year 2 (t+2)	96.15	97.66	-1.5	<.0001
Inpatient HC				
Pre-diagnosis year 2 (t-2)	5.25	5.80	-0.60	0.19
Pre-diagnosis year 1 (t-1)	5.29	6.65	-1.40	<.0001
Diagnosis year (t = 0)	45.22	38.46	6.80	<.0001
Post-diagnosis year 1 (t+1)	21.78	21.14	0.60	0.37
Post-diagnosis year 2 (t+2)	12.50	14.04	-1.5	0.01
Day Surgery				
Pre-diagnosis year 2 (t-2)	8.09	10.81	-2.70	<.0001
Pre-diagnosis year 1 (t-1)	9.49	11.82	-2.30	<.0001
Diagnosis year (t = 0)	42.33	39.73	2.60	0.003
Post-diagnosis year 1 (t+1)	21.57	22.41	-0.80	0.25
Post-diagnosis year 2 (t+2)	15.42	17.38	-2.00	0.004
Physician fees and tests				
Pre-diagnosis year 2 (t-2)	89.67	92.15	-2.50	<.0001
Pre-diagnosis year 1 (t-1)	92.35	93.71	-1.40	0.0019
Diagnosis year (t = 0)	99.95	99.93	0.02	0.59
Post-diagnosis year 1 (t+1)	97.64	98.48	-0.80	0.0003
Post-diagnosis year 2 (t+2)	95.93	97.47	-1.50	<.0001
Emergency Department care				
Pre-diagnosis year 2 (t-2)	1.57	1.53	0.02	0.86
Pre-diagnosis year 1 (t-1)	2.03	2.06	-0.03	0.90
Diagnosis year (t = 0)	10.05	7.11	2.90	<.0001
Post-diagnosis year 1 (t+1)	9.91	8.71	1.20	0.0170
Post-diagnosis year 2 (t+2)	9.80	8.48	1.30	0.0106
Govt. funded drug service				
Pre-diagnosis year 2 (t-2)	17.75	14.50	3.30	<.0001
Pre-diagnosis year 1 (t-1)	19.22	14.78	4.40	<.0001
Diagnosis year (t = 0)	41.77	30.95	10.80	<.0001
Post-diagnosis year 1 (t+1)	46.04	34.60	11.40	<.0001
Post-diagnosis year 2 (t+2)	39.94	29.64	10.30	<.0001
Cancer Care Manitoba Services within 5 years				
Hormone therapy	17.6	12.9	4.7	<.0001
Radiation therapy	32.7	26.8	5.9	<.0001
Chemotherapy	35.1	27.2	7.9	<.0001
Surgery	76.2	81.5	-5.3	<.0001

During the year of cancer diagnosis, healthcare utilization increased significantly for both groups. Immigrants showed greater use of inpatient care (45.22% versus 38.46%), day surgery (42.33% versus 39.73%), emergency department visits (10.05% versus 7.11%), and government-funded drug services (41.77% versus 30.95%) compared to non-immigrants.

In the years following diagnosis, healthcare utilization declined compared with the year of diagnosis but remained higher than pre-diagnosis levels. Immigrants typically reported lower use of physician services (97.64% versus 98.48%) than non-immigrants. In contrast, immigrants were more likely to utilize emergency care services (9.91% versus 8.71%) and government-funded drug programs (46.04% versus 34.60%). There were no significant differences in the use of inpatient care and day surgery between immigrants and non-immigrants during the year following diagnosis. However, in the subsequent year, immigrants exhibited lower use of inpatient care (12.50% versus 14.04%) and day surgery (15.42% versus 17.38%) than non-immigrants.

Additionally, a higher proportion of immigrants used hormone therapy (17.6% versus 12.9%), radiation therapy (32.7% versus 26.8%), and chemotherapy (35.1% versus 27.2%), while a smaller proportion underwent surgery (76.2% versus 81.5%) compared to non-immigrants.

The research further highlights a comparison of mortality rates between immigrants and non-immigrants following a cancer diagnosis. This analysis utilized logistic regression with generalized estimating equations (GEE) within a discrete-time survival model. The mortality rates among immigrants and non-immigrants, detailed in Appendix IV.1, show no significant difference between the two groups.

4.4.2 Comparisons of overall healthcare costs

Table 4.3: Unadjusted and adjusted differences in annual health care costs for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs. non-immigrants.

Time	Immigrants Unadjusted mean Costs (UMC, CA\$) (Obs)	Non- immigrants Unadjusted mean Costs (UMC, CA\$) (Obs)	Unadjusted mean differences in average annual healthcare costs UMd, (95% CI) *	Adjusted mean differences in average annual healthcare costs AMd, (95% CI) **	Adjusted mean differences in average annual healthcare costs AMd, (95% CI) ***
Pre-diagnosis year 2 (t-2)	2046 (4153)	2713 (12715)	-667 (-956, -330)	-1001 (-1379, -583)	-801 (-1070, -505)
Pre-diagnosis year 1 (t-1)	2371 (4288)	2986 (12864)	-615 (-958, -215)	-1077 (-1419, -703)	-849 (-1093, -583)
Diagnosis year (t = 0)	13582 (4288)	12481 (12864)	1100 (404, 1835)	1019 (364, 1853)	645 (114, 1203)
Post-diagnosis year 1 (t+1)	12765 (4288)	10880 (12864)	1885 (229, 3788)	1219 (-31, 2609)	1049 (-196, 2473)
Post-diagnosis year 2 (t+2)	13568 (4001)	15880 (12126)	-2311 (-5536, 1921)	-703 (-2730, 1695)	-674 (-3261, 2567)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, status at last follow-up, and calendar year.

*** Adjusted all variables of model **, except status at last follow-up. *** Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a log-gamma distribution and a first-order autoregressive (AR 1) within-subject correlation for the hurdle model.

Data in Table 4.3 present the mean overall healthcare costs and the difference in mean overall healthcare costs between immigrant and non-immigrant cancer patients, derived from estimates of the adjusted GEE regression model. The unadjusted mean costs (UMC) presented in Table 4.3 indicate that, in the year prior to a cancer diagnosis, immigrants had lower annual healthcare costs (\$2,371 vs. \$2,986) than non-immigrants. However, in the year of diagnosis, immigrants experienced higher annual healthcare costs (\$13,582 vs. \$12,481). The differences in

adjusted mean annual healthcare costs indicate that immigrants incurred significantly lower pre-diagnosis annual healthcare costs (AMd: -1077; 95% CI: -1419, -703 without 2SRI and IPCW; and AMd: -849; 95% CI: -1093, -583 using the 2SRI model with IPCW for pre-diagnosis year) than non-immigrants. Conversely, immigrants incurred significantly higher overall healthcare costs in the year of cancer diagnosis (AMd: 1019; 95% CI: 364, 1853 without the 2SRI-IPCW model; AMd: 645; 95% CI: 114, 1203 with the 2SRI model using IPCW) relative to non-immigrants.

Appendix IV.2 outlines the differences in average healthcare costs between immigrant and non-immigrant cancer patients based on their end-of-follow-up status (survivor or deceased). As indicated in the Appendix, among survivors, immigrants experienced significantly lower annual healthcare costs prior to diagnosis (AMd: -835; 95% CI: -1116, -527, using the 2SRI and IPCW) than non-immigrants. Conversely, in the year of diagnosis (AMd: 1259; 95% CI: 603, 1949 with the 2SRI and IPCW) and in the subsequent year (AMd: 895; 95% CI: 196, 1653 with the 2SRI and IPCW), immigrants incurred significantly higher costs. In contrast, among those who died within three years of diagnosis, there were no significant differences in pre- and post-diagnosis healthcare costs between immigrants and non-immigrants.

4.4.3 Comparisons of healthcare use and costs by services

Table 4.4: Unadjusted and adjusted odds ratios for healthcare utilization and differences in annual healthcare costs by services for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs non-immigrants.

Time	UORs of healthcare use (95% CI) *	UMd in healthcare costs (95% CI) *	AORs of healthcare use (95% CI) **	AMd in healthcare costs (95% CI) **	Adjusted ORs of healthcare use (95% CI) ***	AMd in healthcare costs (95% CI) ***
Inpatient HC						
-2	0.90 (0.77, 1.05)	-280 (-448, -37)	0.89 (0.75, 1.04)	-173 (-502, 276)	0.91 (0.73, 1.14)	-130 (-322, 134)
-1	0.79 (0.68, 0.91)	-270 (-511, 83)	0.73 (0.63, 0.86)	-624 (-888, -276)	0.74 (0.64, 0.87)	-349 (-496, -155)
0	1.32 (1.23, 1.42)	471 (-84, 1075)	1.15 (1.06, 1.24)	881 (212, 1618)	1.15 (1.05, 1.26)	474 (85, 906)
1	1.04 (0.96, 1.13)	617 (-788, 2441)	0.92 (0.84, 1.01)	-29 (-780, 893)	0.96 (0.88, 1.04)	109 (-607, 1076)
2	0.87 (0.79, 0.97)	-2941 (-5459, 1076)	0.78 (0.70, 0.88)	-1081 (-2339, 828)	0.83 (0.74, 0.94)	-917 (-2622, 2041)
Day Surgery						
-2	0.73 (0.64, 0.82)	-46 (-69, -17)	0.69 (0.61, 0.79)	-72 (-98, -41)	0.72 (0.63, 0.82)	-66 (-88, -39)
-1	0.78 (0.65, 0.94)	-45 (-65, -23)	0.74 (0.65, 0.83)	-51 (-76, -22)	0.76 (0.67, 0.85)	-46 (-68, -20)
0	1.11 (1.04, 1.19)	151 (81, 225)	0.99 (0.92, 1.06)	74 (21, 130)	1.00 (0.93, 1.08)	65 (20, 113)
1	0.95 (0.88, 1.04)	-19 (-61, 27)	0.86 (0.79, 0.94)	-65 (-98, -30)	0.88 (0.81, 0.96)	-56 (-84, -25)
2	0.87 (0.79, 0.96)	-62 (-96, -23)	0.79 (0.72, 0.88)	-66 (-101, -26)	0.81 (0.73, 0.89)	-61 (-92, -26)
Physician Services						
-2	0.49 (0.46, 0.52)	-108 (-150, -63)	0.69 (0.61, 0.78)	-137 (-184, -87)	0.75 (0.66, 0.85)	-113 (-153, -71)
-1	0.81 (0.71, 0.93)	-106 (-149, -61)	0.76 (0.66, 0.87)	-120 (-170, -68)	0.80 (0.69, 0.92)	-100 (-143, -57)
0	1.50 (0.32, 6.95)	291 (176, 411)	1.37 (0.31, 5.99)	122 (20, 226)	1.37 (0.31, 6.04)	105 (21, 192)
1	0.64 (0.50, 0.81)	215 (81, 356)	0.60 (0.47, 0.77)	59 (-60, 185)	0.60 (0.47, 0.77)	68 (-35, 176)
2	0.60 (0.50, 0.72)	-129 (-285, 37)	0.57 (0.47, 0.69)	-210 (-353, -58)	0.59 (0.48, 0.72)	-153 (-285, -12)
Emergency						

Department						
-2	1.03 (0.77, 1.36)	-0.58 (-3.6, 3.7)	1.00 (0.75, 1.34)	-3 (-10, 6.6)	1.00 (0.75, 1.34)	-1.4 (-5.4, 4.1)
-1	0.98 (0.77, 1.26)	-2.3 (-5.3, 1.6)	0.95 (0.74, 1.22)	1.7 (-6.6, 13.5)	0.96 (0.75, 1.23)	0.16 (-4.2, 6.2)
0	1.46 (1.29, 1.65)	4.7 (-5.3, 16.5)	1.39 (1.22, 1.58)	15 (3.6, 28.4)	1.40 (1.23, 1.59)	6.9 (0.26, 15)
1	1.15 (1.03, 1.30)	-24 (-49, 5.9)	1.09 (0.97, 1.23)	3.6 (-15, 26)	1.09 (0.97, 1.24)	3 (-11, 19)
2	1.17 (1.04, 1.33)	-70 (-133, 10)	1.13 (0.99, 1.28)	10 (-53, 103)	1.18 (1.04, 1.35)	31 (-36, 136)
Govt. Funded Drug						
-2	1.26 (1.15, 1.38)	-191 (-272, -85)	1.14 (1.03, 1.27)	-248 (-341, -126)	1.09 (0.98, 1.21)	-191 (-272, -85)
-1	1.37 (1.25, 1.50)	-142 (-216, -49)	1.24 (1.12, 1.37)	-197 (-300, -60)	1.18 (1.07, 1.30)	-142 (-217, -49)
0	1.60 (1.49, 1.72)	233 (49, 449)	1.49 (1.37, 1.61)	-70 (-210, 97)	1.41 (1.30, 1.53)	233 (49, 449)
1	1.61 (1.50, 1.73)	1013 (557, 1562)	1.54 (1.43, 1.67)	354 (70, 693)	1.47 (1.36, 1.59)	1013 (557, 1562)
2	1.56 (1.45, 1.67)	940 (296, 1749)	1.51 (1.40, 1.64)	398 (-97, 1036)	1.46 (1.35, 1.59)	940 (296, 1749)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, status at last follow-up, and calendar year. *** Adjusted all variables of model **, except status at last follow-up. *** Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a logit model for healthcare utilization, and a Generalized Estimating Equations (GEE) model with a log-gamma distribution for annual healthcare costs. Both GEEs used a first-order autoregressive (AR1) within-subject correlation in the model.

Table 4.4 presents the odds of healthcare utilization and average healthcare costs by cost sources. For inpatient healthcare, day surgery, and physician service utilization, the adjusted odds ratios from the 2SRI model using IPCW indicate that immigrants had 26%, 24%, and 20% lower odds, respectively, in the year before diagnosis compared to non-immigrants. Conversely, immigrants demonstrated 15% and 40% higher odds of utilizing inpatient care and emergency

department care, respectively, than their non-immigrant counterparts in the year of diagnosis. It is also evident that immigrants had significantly higher odds of using government-funded drugs than non-immigrants, regardless of whether it was before or after the cancer diagnosis. In addition, immigrants had higher average costs for inpatient hospital care (AMd: 474; 95% CI: 85, 906), day surgery (AMd: 65; 95% CI: 20, 113), physician care and screening (AMd: 105; 95% CI: 21, 192), emergency department visits (AMd: 6.9; 95% CI: 0.26, 15) and government-funded drug expenses (AMd: 233; 95% CI: 49, 449) in the year of diagnosis compared to non-immigrants. The findings also indicated that, after the year of diagnosis, immigrants had lower odds of inpatient hospitalization (17%), day surgery (12%), and physician services (40%) than their non-immigrant counterparts. Conversely, they had higher odds of visiting the emergency department (18%) and receiving government-funded medications (47%) (Table 4.4).

Appendix IV.3 presents the odds of healthcare use and average healthcare costs in pre- and post cancer diagnosis, categorized by source and last follow-up status (survivor and deceased). Among the survivor group, the adjusted odds ratios from the 2SRI model indicate that immigrants had 29%, 25%, and 16% lower odds of using inpatient healthcare, day surgery, and physician services, respectively, in the year preceding diagnosis, compared to their non-immigrant counterparts. Conversely, in the year of diagnosis, among the survivors, immigrants had 15% and 43% higher odds of admission to an inpatient hospital and visiting the emergency department, respectively.

The analysis for healthcare utilization at Cancer Care in Appendix IV.4 indicated no significant differences in the adjusted odds of receiving hormone therapy (OR = 0.93; 95% CI: 0.81, 1.07), chemotherapy (OR = 0.95; 95% CI: 0.85, 1.05), and surgery (OR = 1.0; 95% CI: 0.89, 1.11) between immigrants and non-immigrants. However, immigrants had lower odds of

receiving radiation therapy (OR = 0.87; 95% CI: 0.80, 0.96) than their non-immigrant counterparts.

Appendix IV.5 compares annual healthcare costs before and after cancer diagnosis, by sex. The appendix shows that healthcare costs between immigrants and non-immigrants do not vary by sex.

4.4.4 Healthcare costs differences among immigrants by years since immigration

Among immigrant cancer patients presented in Table 4.5, healthcare costs before and after a cancer diagnosis differed based on years since immigration (YSI). A gradient in healthcare costs was observed based on the years since immigration, revealing that immigrants who had been in the country for 10 years or less incurred the highest costs during the diagnosis period (CA\$, 2760; 95% CI: 312, 5543) and post-diagnosis (CA\$, 8906; 95% CI: 4844, 13914) compared to those who had resided in the country for over 20 years. Additionally, immigrants who had been in the country for 10 to 20 years also experienced higher costs than those who had lived in the country for more than 20 years, with costs at the time of diagnosis amounting to CA\$, 3637 (95% CI: 1910, 5517) and CA\$, 3953 (95% CI: 103, 8975) following diagnosis.

Table 4.6 outlines the odds of utilizing healthcare services and the annual average healthcare costs categorized by YSI. For inpatient care, immigrants staying in Canada for less than 11 years demonstrated significantly higher odds of hospital admission in both the years following a cancer diagnosis (aOR: 1.64; 95% CI: 1.32, 2.04, and aOR: 1.86; 95% CI: 1.40, 2.47) when compared to those who resided in Canada for over 20 years.

Table 4.5: Unadjusted and adjusted differences in annual health care costs (\$CA) among international migrant cancer patients diagnosed between 1995 and 2022 by Years Since Immigration (YSI).

Time	Immigrants (YSI ≤ 10) Unadjusted mean Costs, (N)	Immigrants (YSI > 20) Unadjusted mean Costs (N)	Unadjusted mean differences in average annual healthcare costs (95% CI) *	Adjusted mean differences in average annual healthcare costs (95% CI) **	Adjusted mean differences in average annual healthcare costs (95% CI) ***
YSI ≤ 10 vs YSI > 20					
-2	1575 (682)	2183 (2106)	-608 (-1003, -81)	-2073 (-2585, -1457)	-1579 (-2097, -952)
-1	2624 (768)	2281 (2128)	343 (-609, 1838)	-1116 (-1838, -233)	-798 (-1481, 32)
0	17017 (768)	12030 (2128)	4987 (2872, 7402)	284 (-2042, 2910)	2760 (312, 5543)
1	19826 (768)	10009 (2128)	9817 (5731, 14964)	6312 (2773, 10632)	8906 (4844, 13914)
2	18804 (653)	10006 (2038)	8798 (3855, 15502)	8250 (3321, 14730)	13226 (5343, 24420)
10 < YSI ≤ 20 vs YSI > 20	10 < YSI ≤ 20	YSI > 20			
-2	1874 (1672)	2183 (2106)	-309 (-701, 187)	-601 (-1240, 144)	-263 (-902, 488)
-1	2268 (1713)	2281 (2128)	-13 (-512, 626)	-436 (-1027, 242)	-248 (-826, 417)
0	15467 (1713)	12030 (2128)	3437 (2082, 4922)	2887 (993, 4948)	3637 (1910, 5517)
1	12692 (1713)	10009 (2128)	2683 (-607, 7124)	2935 (-42, 6579)	3953 (103, 8975)
2	15663 (1608)	10006 (2038)	5657 (436, 13489)	6502 (1907, 12581)	9539 (2222, 20276)

** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, status at last follow-up, and calendar year. *** Adjusted all variables of model **, except status at last follow-up. *** Model also added IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a log-gamma distribution and a first-order autoregressive (AR 1) within-subject correlation for the hurdle model.

Table 4.6: Unadjusted and adjusted odds ratios for healthcare utilization and differences in annual healthcare costs by services for cancer patients diagnosed between 1995 and 2022, comparing YSI ≤ 10 years vs YSI > 20 (reference group).

	Unadjusted odds ratios of healthcare utilization (95% CI) *	Unadjusted mean differences in average annual healthcare costs (95% CI) *	Adjusted odds ratios of healthcare utilization (95% CI) ***	Adjusted mean differences in average annual healthcare costs (95% CI) ***
Inpatient HC				
YSI ≤ 10 vs YSI > 20				
-2	1.08 (0.72, 1.61)	-303 (-485, 86)	1.24 (0.81, 1.89)	-509 (-859, 136)
-1	1.17 (0.83, 1.67)	469 (-224, 2269)	1.25 (0.87, 1.80)	210 (-399, 1277)
0	1.07 (0.91, 1.27)	3325 (1552, 5510)	1.00 (0.82, 1.22)	1168 (-250, 2974)
1	1.55 (1.28, 1.88)	6198 (2996, 10793)	1.64 (1.32, 2.04)	1391 (159, 3142)
2	1.61 (1.25, 2.07)	5576 (1626, 12168)	1.86 (1.40, 2.47)	2688 (155, 8179)
10<YSI ≤ 20 vs YSI > 20				
-2	1.29 (0.90, 1.84)	-184 (-375, 145)	1.47 (1.01, 2.15)	177 (-334, 968)
-1	1.06 (0.75, 1.49)	5 (-320, 645)	1.17 (0.81, 1.68)	-159 (-501, 346)
0	1.16 (0.91, 1.48)	2256 (1151, 3528)	1.13 (0.86, 1.49)	1198 (171, 2413)
1	1.23 (0.95, 1.58)	1702 (-984, 6528)	1.31 (0.99, 1.73)	1374 (-79, 3611)
2	1.15 (0.93, 1.42)	3856 (-350, 12559)	1.24 (0.99, 1.55)	2808 (16, 9437)
Day Surgery				
YSI ≤ 10 vs YSI > 20				
-2	0.71 (0.50, 0.99)	-66 (-98, -16)	0.96 (0.67, 1.36)	-50 (-98, 27)
-1	0.87 (0.65, 1.15)	-6 (-49, 55)	1.06 (0.79, 1.42)	-17 (-74, 64)
0	0.93 (0.79, 1.10)	153 (-22, 356)	1.01 (0.84, 1.21)	123 (-20, 293)
1	0.88 (0.71, 1.08)	70 (-34, 201)	0.97 (0.78, 1.21)	56 (-24, 159)
2	0.79 (0.62, 1.02)	12 (-71, 125)	0.90 (0.69, 1.18)	-12 (-89, 94)
10<YSI ≤ 20 vs YSI > 20				
-2	0.79 (0.58, 1.09)	-38 (-73, 12)	0.90 (0.65, 1.24)	-15 (-58, 43)
-1	0.77 (0.57, 1.04)	-29 (-59, 10)	0.85 (0.62, 1.16)	-7 (-56, 58)
0	1.04 (0.82, 1.33)	134 (6, 277)	1.09 (0.84, 1.41)	148 (41, 269)
1	1.04 (0.81, 1.34)	30 (-44, 120)	1.10 (0.85, 1.44)	31 (-26, 100)
2	0.73 (0.60, 0.88)	-85 (-131, -26)	0.77 (0.63, 0.95)	-65 (-119, 7)
Physician Services				
YSI ≤ 10 vs YSI > 20				
-2	0.43 (0.33, 0.55)	-126 (-212, -28)	0.55 (0.40, 0.75)	-164 (-279, -36)
-1	0.72 (0.53, 0.98)	-50 (-144, 57)	0.90 (0.63, 1.28)	-97 (-218, 37)
10<YSI ≤ 20 vs YSI > 20				
-2	0.60 (0.45, 0.80)	-90 (-157, -15)	0.65 (0.48, 0.88)	-60 (-150, 38)
-1	0.60 (0.48, 0.77)	-50 (-124, 31)	0.63 (0.48, 0.81)	-7 (-111, 106)
Emergency Department				
YSI ≤ 10 vs YSI > 20				

	Unadjusted odds ratios of healthcare utilization (95% CI) *	Unadjusted mean differences in average annual healthcare costs (95% CI) *	Adjusted odds ratios of healthcare utilization (95% CI) ***	Adjusted mean differences in average annual healthcare costs (95% CI) ***
-2	1.67 (0.89, 3.15)	-4 (-7, 2)	1.45 (0.76, 2.79)	-6 (-10, 1.4)
-1	0.92 (0.52, 1.63)	-7 (-11, 0.87)	0.80 (0.45, 1.44)	-11 (-15, -3)
0	1.78 (1.38, 2.29)	2.6 (-18, 31)	1.54 (1.18, 2.02)	5 (-9, 26)
1	2.37 (1.84, 3.04)	116 (33, 241)	2.08 (1.59, 2.72)	186 (95, 321)
2	1.43 (1.07, 1.93)	17 (-93, 191)	1.22 (0.90, 1.65)	22 (-38, 120)
10<YSI ≤ 20 vs YSI > 20				
-2	1.27 (0.71, 2.26)	-0.65 (-5, 8.4)	1.28 (0.71, 2.30)	-1 (-7, 8)
-1	0.85 (0.51, 1.42)	-5 (-10, 1.1)	0.86 (0.52, 1.44)	-7 (-12, 0.51)
0	1.31 (0.95, 1.82)	-9 (-24, 11)	1.29 (0.92, 1.80)	11 (-3, 30)
1	1.32 (0.95, 1.82)	116 (33, 241)	1.31 (0.93, 1.85)	40 (4, 91)
2	1.16 (0.92, 1.15)	8 (-90, 156)	1.17 (0.92, 1.48)	164 (4, 505)
Govt. Funded Drug				
YSI ≤10 vs YSI > 20				
-2	1.09 (0.87, 1.36)	-161 (-238, -40)	1.32 (1.04, 1.68)	-539 (-698, -288)
-1	1.14 (0.92, 1.40)	-104 (-190, 23)	1.32 (1.05, 1.64)	-606 (-798, -308)
0	1.55 (1.32, 1.84)	837 (321, 1569)	1.95 (1.58, 2.39)	1227 (-101, 3359)
1	1.56 (1.32, 1.85)	2003 (465, 4464)	1.92 (1.58, 2.34)	3751 (564, 8909)
10<YSI ≤ 20 vs YSI > 20				
-2	1.02 (0.83, 1.24)	-50 (-173, 152)	1.20 (0.96, 1.49)	-123 (-425, 343)
-1	0.99 (0.81, 1.20)	-14 (-132, 162)	1.12 (0.91, 1.39)	-466 (-687, -140)
0	1.23 (1.05, 1.45)	419 (79, 876)	1.48 (1.22, 1.79)	752 (-68, 1874)
1	1.28 (1.13, 1.46)	470 (-247, 1463)	1.53 (1.28, 1.83)	2395 (247, 5497)
2	1.19 (1.04, 1.37)	1185 (-4, 2979)	1.40 (1.20, 1.64)	8252 (2040, 19145)

*** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, and calendar year. *** Model used IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a logit model for healthcare utilization, and a Generalized Estimating Equations (GEE) model with a log-gamma distribution for annual healthcare costs. Both GEEs used a first-order autoregressive (AR1) within-subject correlation in the hurdle model.

Additionally, the average annual inpatient healthcare costs for those utilizing inpatient services were notably higher during the year of diagnosis (Amd: 1391; 95% CI: 159, 3142) as well as in the year subsequent to diagnosis (Amd: 2688; 95% CI: 155, 8179) for immigrants with less than 11 years of residency, relative to their counterparts with over 20 years in Canada.

Immigrants who had resided in Canada for less than 11 years or those who had lived in Canada for more than 10 but less than 20 years both had lower odds of visiting a physician (aOR: 0.55; 95% CI: 0.40, 0.75 and aOR: 0.65; 95% CI: 0.48, 0.88, respectively) prior to a cancer diagnosis than those who had resided for more than 20 years.

In the context of emergency department care, immigrants who had resided in Canada for less than 11 years demonstrated higher odds of seeking care both at the time of cancer diagnosis (aOR: 1.54; 95% CI: 1.18, 2.02) and following year after cancer diagnosis (aOR: 2.08; 95% CI: 1.59, 2.72) when compared to those who had lived in Canada for over 20 years. Average costs of emergency department visits among recent immigrants were higher in the year following their diagnosis (Amd: 186; 95% CI: 95, 321) compared with their counterparts with more than 20 years of residency. Furthermore, the data indicated that recent immigrants had significantly higher odds of utilizing government-funded medications than those immigrants resided for over 20 years, regardless of whether this occurred before or after their cancer diagnosis.

The sensitivity analysis excludes individuals diagnosed with stage 4 cancer and/or non-melanoma skin cancer, as shown in Appendix IV.6 It reveals no differences compared with the main study results.

4.5 Discussion

4.5.1 Main findings

- 1) Compared to non-immigrants, immigrants used healthcare services less and had lower overall healthcare costs before a new cancer diagnosis. The only exception was in the use of government-funded drug services. Additionally, this difference in healthcare use before diagnosis was especially noticeable among survivors.

- 2) In the year of a cancer diagnosis, immigrants had higher overall healthcare costs, especially among survivors, and were more likely to be hospitalized overnight, visit emergency departments, and access government-funded drug services compared to non-immigrants.
- 3) A gradient in healthcare costs was observed according to years since immigration, with the highest costs among recent immigrants and progressively lower costs among those with longer duration of residence. Recently arrived immigrants (with a residency of less than 11 years) incurred lower pre-diagnosis costs but experienced (with a residency of less than 21 years) higher overall costs at and after their diagnosis compared to immigrants who had been in Canada for over 20 years.
- 4) Recent immigrants had lower odds of visiting a physician prior to their cancer diagnosis and had higher odds of being admitted to an inpatient hospital and visiting the emergency department (ED) after their cancer diagnosis compared to those who had been in Canada for more than 20 years.

4.5.2 limitations

This research could not include cost information for hormone therapy, radiation therapy, and chemotherapy services received by individuals from Cancer Care Manitoba because these data are not available at the Manitoba population research data repository. The cancer stage dataset is incomplete, as the stage for some cancer patients could not be assessed because the T (primary tumours), M (distant metastases) and N (regional lymph nodes), were unknown (approximately 10%). In addition, in some cases, approximately 25% of T, N, and M were missing because their nature could not be ascertained. The missing data were mainly for all other cancer sites outside the four main sites, including breast, lung, colorectal, and prostate.

Furthermore, the study did not account for out-of-pocket healthcare expenses incurred in the study period, particularly drug costs. Another limitation is that it does not include temporary residents with a study permit and work permit holders. Therefore, the results of this study may not be generalized to all foreign-born populations.

The study used the 2SRI model, controlling for region of origin, economic immigrants (yes/no), and refugee status (yes/no) to address unobserved factors and selection bias, as they are time-invariant and do not directly influence eligibility for healthcare coverage. But among the refugee claimants waiting for a work permit, they were covered by a federal program while awaiting permanent residency. Unfortunately, I could not differentiate them from the broader refugee group, though many were not refugee claimants.

Finally, a limitation of this study is that, although it identifies unobserved factors that influence immigrants' comorbidities and significantly affect their healthcare use and costs, it does not detail the specific pre- and post-immigration confounding factors. As a result, the study does not clarify what factors contribute to lower healthcare use and costs among immigrants

4.5.3 Interpretation

Immigrants had fewer physician care visits and utilized lower inpatient and outpatient hospital services, except for government-funded prescription drugs prior to cancer diagnosis, than non-immigrants within the universal health care system in Manitoba, Canada. As a result, the overall average annual healthcare costs of immigrants prior to cancer diagnosis were lower than those of non-immigrants. The findings of lower healthcare utilization prior to cancer diagnosis are consistent with a study comparing preoperative healthcare utilization among patients undergoing Emergency General Surgery (EGS) in British Columbia (Guo et al., 2026). They found that the year prior to undergoing EGS, immigrants had fewer primary care visits,

imaging services, special consults, and ED visits. Another study conducted by Greenaway et al. in 2018 in Canada revealed that the absence of routine pre- and post-arrival hepatitis C screening in Canada creates major barriers to patient care for immigrants. The challenges include language difficulties, low health literacy, transportation issues, prolonged waiting times, and obstacles to integration (Pandey et al., 2022; Fuller-Thomson & George, 2011; Pandey et al., 2021), which contribute to lower healthcare utilization.

Additionally, systemic barriers within the healthcare system hinder access to necessary healthcare and treatment, contributing to delays in diagnosis and treatment (Greenaway et al., 2018). Interestingly, the observation of reduced healthcare use and lower overall healthcare costs among immigrants compared to non-immigrants before their diagnosis may be partly explained by the "healthy immigrant effect," especially among survivors. This phenomenon suggests that migrants may initially be healthier than the Canadian-born (Debbarman et al, 2023; Vang et al., 2017), which may affect their medical needs.

This research also revealed that immigrants incurred higher overall healthcare costs, especially among survivors, and were more likely to visit the emergency department, be admitted to inpatient hospital care, and use government-funded medications in the year of their cancer diagnosis compared to non-immigrants. It may be due to delayed access to healthcare, as evidenced by the higher odds of visiting the ED among immigrants in the year of diagnosis. The study aligns with the findings of CIHI (2026) and Scott and Hoshin (2024), which indicated that limited access to high-quality primary care can allow minor health issues to develop into life-altering chronic diseases.

This progression leads to increasingly complex care needs, more frequent visits to the emergency department, and reduced uptake of preventive care, all of which contribute to

elevated healthcare demands and costs (CIHI, 2026; Scott and Hoshin, 2024). Routine healthcare prior to cancer diagnosis, including symptom awareness and regular screening, could lead to earlier disease detection and contribute to reduced cancer severity at the initial stage (Loften et al., 2021; Kalyta et al., 2021; Chintala et al., 2025).

The advantage of lower annual healthcare costs prior to cancer diagnosis is partly captured by healthy-immigration effects among recently arrived immigrants (Vang et al., 2017; Debbarman et al., 2023). In addition, the findings align with existing research, indicating that difficulties in accessing primary care are exacerbated by a physician shortage, which disproportionately impacts immigrant sub-groups (Kiran et al., 2022; Saunders et al., 2021).

Routine use of primary care prior to a cancer diagnosis is linked to a significant decrease in metastatic disease at the time of diagnosis and lower cancer-related mortality (Edmund et al., 2022). Patients diagnosed with cancer in the emergency department (ED) tend to have poorer outcomes compared to those diagnosed through other facilities (Grewal et al., 2024; Kang et al., 2023; Delamare et al., 2013). The findings reveal that recent immigrants exhibit lower healthcare utilization prior to a cancer diagnosis and incur higher healthcare costs afterward, suggesting insufficient integration into the healthcare system. This observation aligns with existing literature, which indicates that healthcare utilization patterns tend to vary based on the duration of residence; those who have lived longer in the country often show greater integration into healthcare systems and enjoy improved access to consistent sources of care (Ravichandiran et al., 2022; Ogungbe et al., 2022).

4.5.4 Implications

Research indicates that immigrants are less likely to utilize physician services and inpatient care prior to a cancer diagnosis. Instead, they are more likely to visit the emergency

department and be hospitalized during the cancer diagnosis phase. This trend is particularly evident among recent immigrants who face numerous barriers to accessing healthcare, including language difficulties, challenges in securing a family doctor, transportation issues, job responsibilities, and a lack of familiarity with the healthcare system. To address these challenges, authorities could implement policies that facilitate recent immigrants' easier access to a family physician. Additionally, promoting settlement services and community organizations that provide language training and information about healthcare programs could be beneficial for recent immigrants. Providing culturally and linguistically accessible healthcare is essential for enabling recent immigrants to effectively communicate their health concerns with healthcare providers. These initiatives could significantly increase the participation of immigrants, particularly recent arrivals, in cancer screening programs, which in turn may lead to earlier diagnoses and timely treatment.

4.6 Conclusion

This study examined patterns of healthcare utilization and costs surrounding a new cancer diagnosis, focusing on the differences between immigrants and non-immigrants. Prior to the diagnosis, immigrants exhibited lower rates of healthcare service use and incurred lower healthcare costs compared to their non-immigrant counterparts. However, during the year of diagnosis, immigrants showed a significant increase in visits to the emergency department and hospitalizations, contributing to higher overall healthcare costs among survivors. The patterns of healthcare utilization and associated costs before and after cancer diagnosis among immigrants differed based on their years since immigration.

4.7 References:

- Agic, B., Mann, R. E., Tuck, A., Ialomiteanu, A., Bondy, S., Simich, L., & Ilie, G. (2016). Alcohol use among immigrants in Ontario, Canada. *Drug and Alcohol Review*, 35(2), 196–205.
- Asanin J, Wilson K. “I spent nine years looking for a doctor”: Exploring access to health care among immigrants in Mississauga, Ontario, Canada. *Soc Sci Med*. 2008;66(6):1271-1283.
- Alsayheen, E. A., Aldiabat, K., & Aquino-Russell, C. (2022). The lived experiences of middle eastern immigrant women during their cancer survivorship journey: A phenomenological study. *The Qualitative Report*, 27(8), 1660-1688.
- Baldi, I., Pagano, E., Berchialla, P., Desideri, A., Ferrando, A., Merletti, F., & Gregori, D. (2013). Modeling healthcare costs in simultaneous presence of asymmetry, heteroscedasticity and correlation. *Journal of Applied Statistics*, 40(2), 298–310.
- Barnett, E. D., Wheelock, A. B., MacLeod, W. B., McCarthy, A. E., Walker, P. F., Coyle, C. M., Greenaway, C. A., Castelli, F., López-Vélez, R., Gobbi, F. G., Trigo, E., Grobusch, M. P., Gautret, P., Hamer, D. H., Kuhn, S., & Stauffer, W. M. (2023). Infections with long latency in international refugees, immigrants, and migrants seen at GeoSentinel sites, 2016–2018. *Travel Medicine and Infectious Disease*, 56, Article 102653.
- Brenner, D., Gillis, J., Nicolau, I., Demers, A., Ellison, L., Finley, C., Fitzgerald, N., Jacquel, S. N., Shack, L., Turner, D., Woods, R., (2024). Canadian Cancer Statistics: *A 2024 special report in Canada*. Canadian Cancer Society.
- Brown, K. F., Rumgay, H., Dunlop, C., Ryan, M., Quartly, F., Cox, A., Deas, A., Elliss-Brookes, L., Gavin, A., Hounsoms, L., Huws, D., Ormiston-Smith, N., Shelton, J., White, C., & Parkin, D. M. (2018). The fraction of cancer attributable to modifiable risk factors in England, Wales, Scotland, Northern Ireland, and the United Kingdom in 2015. *British Journal of Cancer*, 118(8), 1130–1141.
- Buntin, M. B., & Zaslavsky, A. M. (2004). Too much ado about two-part models and transformation? Comparing methods of modeling Medicare expenditures. *Journal of Health Economics*, 23(3), 525–542.
- Canadian Centre for Cancer Information. (2023). Cancer incidence. Retrieved from <https://cancer-data.canada.ca/stats/incidence-eng.htm>.
- Canadian Centre for Cancer Information. (2023). Cancer mortality. Retrieved from <https://cancer-data.canada.ca/stats/mortality-mortalite-eng.htm>.
- Canadian Institute for Health Information. *Better access to primary care key to improving health of Canadians*. Accessed July 5, 2026.
- Cancer Care Manitoba (2010). Cancer in Manitoba: *Annual Statistics Report 2010*. <https://www.cancercare.mb.ca/export/sites/default/Research/.galleries/files/epidemiology->

cancer-registry-reports.

files/cancerincidence/CCMB_2010_Annual_Statistical_Report_Apr13.pdf.

Cancer Care Manitoba (2011). Tomorrow starts today:2010/2011 progress report.

https://www.cancercare.mb.ca/export/sites/default/About-Us/.galleries/files/corporate-publications/CCMB_Progress_Report_2010-2011.pdf

Cancer Care Manitoba (2021). *Cancer in Manitoba: Annual Statistics Report*

2021.<https://www.cancercare.mb.ca/export/sites/default/Research/.galleries/files/epidemiology-cancer-registry-reports-files/cancer-incidence/2021-Annual-Statistical-Report.pdf>.

Cancer Care Manitoba (2024). Annual Progress Report-

2024.https://www.cancercare.mb.ca/export/sites/default/About-Us/.galleries/files/corporate-publications/Annual-Progress-Report-2024_compressed.pdf

Caraballo, R. S., Giovino, G. A., Pechacek, T. F., Mowery, P. D., Richter, P. A., Strauss, W. J., Sharp, D. J., Eriksen, M. P., Pirkle, J. L., & Maurer, K. R. (1998). Racial and Ethnic Differences in Serum Cotinine Levels of Cigarette Smokers: Third National Health and Nutrition Examination Survey, 1988-1991. *JAMA : The Journal of the American Medical Association*, 280(2), 135–139.

Castelli F, Sulis G. (2017). Migration and infectious diseases. *Clin Microbiol Infect.* 23(5):283289.

Cheung, M. C., Earle, C. C., Fischer, H. D., Camacho, X., Liu, N., Saskin, R., Shah, B. R., Austin, P. C., & Singh, S. (2017). Impact of Immigration Status on Cancer Outcomes in Ontario, Canada. *Journal of Oncology Practice*, 13(7), e602–e612.

Cheung, M. C., Earle, C., Fischer, H., Camacho, X., Saskin, R., Shah, B., Austin, P., & Singh, S. (2016). The impact of immigration status on cancer outcomes in Ontario, Canada. *Journal of Clinical Oncology*, 34(7_suppl), 285–285.

Chintala, S. R., Morgan, K. M., Qiao, E. M., Minarim, D. S., Duran, E. A. M., Demb, J., Murphy, J. D., Banegas, M., & Rose, B. S. (2025). Impact of Prior Primary Care Utilization on Metastatic Disease and Mortality in Colorectal Cancer. *International Journal of Radiation Oncology, Biology, Physics*, 123(1), e634–

Chu, A., Barbera, L., Sutradhar, R., Oz, U. E., O’Leary, E., & Seow, H. (2021). Association between end-of-life cancer care and immigrant status: a retrospective cohort study in Ontario, Canada. *BMJ Open*, 11(6), e042978–e042978.

Dasgupta, P., Baade, P. D., Aitken, J. F., Ralph, N., Chambers, S. K., & Dunn, J. (2019). Geographical Variations in Prostate Cancer Outcomes: A Systematic Review of International Evidence. *Frontiers in oncology*, 9, 238.

Dastjerdi M. The case of Iranian immigrants in the greater Toronto area: A qualitative study. *Int J Equity Health*. 2012;11(1):1-8. doi:10.1186/1475-9276-11-9.

- Debbarman, S., Prior, H., Walld, R., & Urquia, M. L. (2023). Assessing the migrant mortality advantage among foreign-born and interprovincial migrants in Manitoba, Canada. *Canadian Journal of Public Health*, 114(3), 441–452.
- Delamare Fauvel A, Bischof JJ, Reinbolt RE, et al. (2023). Diagnosis of cancer in the emergency department: a scoping review. *Cancer Med*, 12(7):8710–8728.
- Di Napoli A, Ventura M, Spadea T, et al. (2022). Barriers to accessing primary care and appropriateness of healthcare among immigrants in Italy. *Front Public Health*, 10:817696.
- Farion KJ, Wright M, Zemek R, et al. (2015). Understanding low-acuity visits to the pediatric emergency department. *PLoS One*, 10(6): e0128927.
- Ferrer, A. M., Picot, G., & Riddell, W. C. (2014). New Directions in Immigration Policy: Canada’s Evolving Approach to the Selection of Economic Immigrants. *The International Migration Review*, 48(3), 846–867.
- Fuller-Thomson, E., Noack, A. M., and George, U. (2011). Health Decline Among Recent Immigrants to Canada: Findings from a Nationally Representative Longitudinal Survey. *Canadian Journal of Public Health*, 102(4): 273–280.
- Gormley, M., Creaney, G., Schache, A., Ingarfield, K., & Conway, D. I. (2022). Reviewing the epidemiology of head and neck cancer: definitions, trends and risk factors: Reviewing the epidemiology of head and neck cancer: definitions, trends and risk factors. *British Dental Journal*, 233(9), 780–786.
- Grande, R., García-González, J. M., & Stanek, M. (2023). Differences in the risk of premature cancer mortality between natives and immigrants in Spain. *European Journal of Public Health*, 33(5), 803–808.
- Greenaway C, Castelli F. (2019). Infectious diseases at different stages of migration: an expert review. *Journal of Travel Medicine*. 26(2):taz007.
- Guo, M., Mourad, N., Karimuddin, A., & Sutherland, J. (2026). Comparing Preoperative Healthcare Utilization Between Immigrants and Non-Immigrants Undergoing Emergency General Surgery in British Columbia. *Journal of Immigrant and Minority Health*. 10.1007/s10903-026-01847-6.
- Hernán MA, Robins J. (2016). Causal Inference Book. Boca Raton, FL: Chapman & Hall/CRC.
- Hernán, M. A., Hernández-Díaz, S., & Robins, J. M. (2004). A Structural Approach to Selection Bias. *Epidemiology (Cambridge, Mass.)*, 15(5), 615–625.
- Holz, M. (2022). Health inequalities in Germany: differences in the “Healthy migrant effect” of European, non-European and internal migrants. *Journal of Ethnic and Migration Studies*, 48(11): 2620–2641.
- Howe, C. J., Cole, S. R., Lau, B., Napravnik, S., & Joseph J., E. (2016). Selection Bias Due to Loss to Follow Up in Cohort Studies. *Epidemiology (Cambridge, Mass.)*, 27(1), 91–97.

Hwee, J., & Bougie, E. (2021). Do cancer incidence and mortality rates differ among ethnicities in Canada? *Health Reports*, 32(8), 3–17.

Immigration, Refugees and Citizenship Canada. *Evaluation of the Health Screening and Notification Program*. Ottawa: Immigration, Refugees and Citizenship Canada, 2015.

Iqbal, J., Ginsburg, O., Fischer, H. D., Austin, P. C., Creatore, M. I., Narod, S. A., & Rochon, P. A. (2017). A Population-Based Cross-Sectional Study Comparing Breast Cancer Stage at Diagnosis between Immigrant and Canadian-Born Women in Ontario. *The breast journal*, 23(5), 525–536.

Jennum, P., Debes, N. M. M., Ibsen, R., & Kjellberg, J. (2021). Long-term employment, education, and healthcare costs of childhood and adolescent onset of epilepsy. *Epilepsy & Behavior*, 114(Pt A), Article 107256.

Kalyta, A., De Vera, M. A., Peacock, S., Telford, J. J., Brown, C. J., Donnellan, F., Gill, S., & Loree, J. M. (2021). Canadian Colorectal Cancer Screening Guidelines: Do They Need an Update Given Changing Incidence and Global Practice Patterns? *Current Oncology (Toronto)*, 28(3), 1558–1570.

Kang S, McLeod SL, Walsh C, Grewal K. (2023). Patient outcomes associated with cancer diagnosis through the emergency department: a systematic review. *Acad Emerg Med*, 30(9):955–962.

Kiran T, Green ME, Wu CF, et al. (2022). Family Physicians Stopping Practice During the COVID-19 Pandemic in Ontario, *Canada. Ann Fam Med*, 20(5):460–463.

Kumar, B. N., & Diaz, E. (2019). *Migration and health: Primary care perspective*. Boca Raton: Taylor and Francis.

Kumar, R. (2021). Refugee Articulations of Health: A Culture-Centred Exploration of Burmese Refugees' Resettlement in the United States. *Health Communication*, 36(6), 682–692.

Lamminmäki, M., Leivonen, A., Heinävaara, S., Nygård, M., Ursin, G., Campbell, S., Stefansdóttir, H., Hirvonen, E., Toikkanen, S., Vejborg, I. M. M., Njor, S. H., & Sarkeala, T. (2023). A population-based cohort study on changes in breast, lung and colorectal cancer incidence and mortality among non-Western immigrant women. *BMC Cancer*, 23(1), 665–665.

Lange, S., Glatz, T., & Eiset, A. H. (2024). Association of pre-migration socioeconomic status and post-migration mental health in Syrian refugees in Lebanon: a descriptive sex-stratified cross-sectional analysis. *Global Health Research and Policy*, 9(1), Article 9.

Liang, K. Y., & Zeger, S. L. (1986). Longitudinal data analysis using generalized linear models. *Biometrika*, 73(1), 13–22.

Liu, L., Huang, X., & O'Quigley, J. (2008). Analysis of Longitudinal Data in the Presence of Informative Observational Times and a Dependent Terminal Event, with Application to Medical Cost Data. *Biometrics*, 64(3), 950–958.

- Lofters, A. K., Gatov, E., Lu, H., Baxter, N. N., Corrado, A. M., Guilcher, S. J. T., Kopp, A., Vahabi, M., & Datta, G. D. (2021). Stage of colorectal cancer diagnosis for immigrants: a population-based retrospective cohort study in Ontario, Canada. *Cancer Causes & Control*, 32(12), 1433–1446.
- Lofters, A. K., McBride, M. L., Li, D., Whitehead, M., Moineddin, R., Jiang, L., Grunfeld, E., Groome, P. A., Biswanger, N., Decker, K., Kendell, C., Krzyzanowska, M., Mittmann Matthias, S. N., Porter, G., Powell, D., Turner, D., Vick, B., Winget, M., & Yuan, Y. (2019). Disparities in breast cancer diagnosis for immigrant women in Ontario and BC: Results from the CanIMPACT study. *BMC Cancer*, 19(1), 42–42.
- Lofters, A. K., Sammott, S.-A., Swayze, S., Bender, J. L., Alibhai, S. M. H., Henry, A., Noel, K., & Datta, G. (2024). Stage of diagnosis and survival for prostate cancer among immigrant men in Ontario, Canada. *Cancer Epidemiology*, 90, 102562–102562.
- Lu, C., & Ng, E. (2019). Healthy immigrant effect by immigrant category in Canada. *Health Reports*, 30(4), 3–11.
- Lu, Y., Kaushal, N., Denier, N., and Wang, J. S.-H. (2017). Health of newly arrived immigrants in Canada and the United States: Differential selection on health. *Health and Place*, 48: 1–10.
- Malagón, T., Botting-Provost, S., Moore, A., El-Zein, M., Franco, E. L. (2024). Inequalities in relative cancer survival by race, immigration status, income, and education for 22 cancer sites in Canada, a cohort study. *MedRxiv*, 1 -24.
- Malagón, T., Morais, S., Tope, P., El-Zein, M., & Franco, E. L. (2023). Site-specific cancer incidence by race and immigration status in Canada 2006-2015: a population-based data linkage study. *Cancer Epidemiology, Biomarkers & Prevention*, 32(7), 906–918.
- Malehi, A. S., Pourmotahari, F., & Angali, K. A. (2015). Statistical models for the analysis of skewed healthcare cost data: A simulation study. *Health Economics Review*, 5(11), Article 11.
- Manitoba Health. (2024). Manitoba Healthcare Coverage. Website: <https://www.gov.mb.ca/health/mhsip/index.html>
- Markkula N, Cabieses B, Lehti V, Uphoff E, Astorga S, Stutzin F. (2018). Use of health services among international migrant children—a systematic review. *Global Health*. 2018;14(1):52.
- Masyn, K. E. (2013). *Discrete-Time Survival Analysis*. In *Prevention Science* (pp. 35–57). Springer.
- McCauley, L., Phillips, R. L., Meisnere, M., and Robinson, S. K. National Academies of Sciences, E. (2021). *Implementing High-Quality Primary Care: Rebuilding the Foundation of Health Care*. (1st ed.). National Academies Press.
- McDonald T. J., Kennedy S. (2005). Is migration to Canada associated with unhealthy weight gain? Overweight and obesity among Canada’s immigrants. *Social Science and Medicine*, 61: 2469–2481.

- McDonald, J. T., Farnworth, M., & Liu, Z. (2017). Cancer and the healthy immigrant effect: a statistical analysis of cancer diagnosis using a linked Census-cancer registry administrative database. *BMC Public Health*, 17(1), 296–296.
- McKinlay, J. B. (1975). Who is Really Ignorant--Physician or Patient? *Journal of Health and Social Behavior*, 16(1), 3–11.
- Mills A. (2014). Health care systems in low- and middle-income countries. *The New England journal of medicine*, 370(6), 552–557.
- Müller, M., Khamis, D., Srivastava, D., Exadaktylos, A., & Pfortmueller, C. (2018). Understanding refugees' health. *Seminars in Neurology*, 38(2), 152–162.
- Nabi, H., Ibsen, R., Ibsen, M., Kjellberg, J., Hetland, M. L., & Glintborg, B. (2024). Counting the costs: a nationwide study on healthcare use following an adalimumab biosimilar switch in >1300 inflammatory arthritis patients. *Therapeutic Advances in Musculoskeletal Disease*, 16, 1759720X241289391.
- Ng E., Pottie K., Spitzer D. (2011). Official language proficiency and self-reported health among immigrants to Canada. *Health Reports*, 22(4): 15–23.
- Ng, E. (2011). The healthy immigrant effect and mortality rates. *Health Reports*, 22(4), 9–25.
- Niraula, A., Ratti, N., Colley, M., Rosenberg, M., Ghassemi, E., and Wilson, K. (2023). Negotiating precarity: Recent immigrants' perceptions of waiting for public healthcare in Ontario, Canada. *Health Policy (Amsterdam)*, 133: 104843–104843.
- Ogungbe, O., Turkson-Ocran, R.-A., Koirala, B., Byiringiro, S., Liu, X., Elias, S., Mensah, D., Turkson-Ocran, E., Nkimbeng, M., Cudjoe, J., Baptiste, D., & Commodore-Mensah, Y. (2022). Acculturation and Cardiovascular Risk Screening among African Immigrants: The African Immigrant Health Study. *International Journal of Environmental Research and Public Health*, 19(5), Article 2556.
- Ontario Health (Cancer Care Ontario). Ontario Cancer Statistics 2022. Toronto: Ontario Health (Cancer Care Ontario); 2022
- Pandey, M., Kamrul, R., Michaels, C. R., & McCarron, M. (2022). Identifying Barriers to Healthcare Access for New Immigrants: A Qualitative Study in Regina, Saskatchewan, Canada. *Journal of Immigrant and Minority Health*, 24(1), 188–198.
- Parvez, E., Chu, M., Kirkwood, D., Doumouras, A., Levine, M., & Bogach, J. (2023). Patient reported symptom burden amongst immigrant and Canadian long-term resident women undergoing breast cancer surgery. *Breast Cancer Research and Treatment*, 199(3), 553–563.
- Patel, A., Dean, J., Edge, S., Wilson, K., and Ghassemi, E. (2019). Double burden of rural migration in Canada? Considering the social determinants of health related to immigrant settlement outside the cosmopolis. *International Journal of Environmental Research and Public Health*, 16(5): 678-.

- Pérez-Stable, E. J., Herrera, B., Jacob III, P., & Benowitz, N. L. (1998). Nicotine Metabolism and Intake in Black and White Smokers. *JAMA : The Journal of the American Medical Association*, 280(2), 152–156.
- Poirier, A. E., Ruan, Y., Volesky, K. D., King, W. D., O’Sullivan, D. E., Gogna, P., Walter, S. D., Villeneuve, P. J., Friedenreich, C. M., & Brenner, D. R. (2019). Corrigendum to “The current and future burden of cancer attributable to modifiable risk factors in Canada: Summary of results” [Prev. Med. 122 (2019) 140–147]. *Preventive Medicine*, 129, 105732–105732.
- Quach, B. I., Qureshi, D., Talarico, R., Hsu, A. T., & Tanuseputro, P. (2021). Comparison of End-of-Life Care Between Recent Immigrants and Long-standing Residents in Ontario, Canada. *JAMA Network Open*, 4(11), Article 2132397.
- Ravichandiran, N., Mathews, M., and Ryan, B. L. (2022). Utilization of healthcare by immigrants in Canada: a cross-sectional analysis of the Canadian Community Health Survey. *BMC Family Practice*, 23(1): 69–69.
- Rivera-Hernandez, M., Kumar, A., Chou, L.-N., Keeney, T., Ferdows, N., Karmarkar, A., Markides, K. S., & Ottenbacher, K. (2022). Healthcare utilization and costs among high-need and frail Mexican American Medicare beneficiaries. *PloS One*, 17(1), Article e0262079.
- Robins JM, Rotnitzky A, Zhao LP. (1995). Analysis of semiparametric regression models for repeated outcomes in the presence of missing data. *Journal of the American Statistical Association*. 90:106–121.
- Ruan, Y., Poirier, A., Yong, J., Garner, R., Sun, Z., Then, J., & Brenner, D. R. (2023). Long-term projections of cancer incidence and mortality in Canada: The OncoSim All Cancers Model. *Preventive medicine*, 168, 107425.
- Salami, B., Mason, A., Salma, J., Yohani, S., Amin, M., Okeke-Ihejirika, P., & Ladha, T. (2020). Access to healthcare for immigrant children in Canada. *International Journal of Environmental Research and Public Health*, 17(9), 3320-.
- Saunders N, Guttmann A, Brownell M, et al. (2021). Pediatric primary care in Ontario and Manitoba after the onset of the COVID-19 pandemic: a population-based study. *CMAJ Open*, 9(4): E1149-E1158.
- Schlagenhauf P, Grobusch MP, Hamer DH, et al. (2018). Area of exposure and treatment challenges of malaria in Eritrean migrants: a GeoSentinel analysis. *Malaria J.*17:443.
- Scott, E. C. S., & Hoskin, P. J. (2024). Health inequalities in cancer care: a literature review of pathways to diagnosis in the United Kingdom. *E Clinical Medicine*, 76, Article 102864.
- Seaman S, Copas A. (2009). Doubly robust generalized estimating equations for longitudinal data. *Statistics in medicine*, 28:937–955.

Shuldiner, J., Liu, Y., & Lofters, A. (2018). Incidence of breast and colorectal cancer among immigrants in Ontario, Canada: a retrospective cohort study from 2004-2014. In *BMC Cancer* (Vol. 18, Number 1).

Smith-Warner, S. A., Spiegelman, D., Yaun, S., Albanes, D., Beeson, W. L., van den Brandt, P. A., Feskanich, D., Folsom, A. R., Fraser, G. E., Freudenheim, J. L., Giovannucci, E., Goldbohm, R. A., Graham, S., Kushi, L. H., Miller, A. B., Pietinen, P., Rohan, T. E., Speizer, F. E., Willett, W. C., & Hunter, D. J. (2003). Fruits, vegetables and lung cancer: A pooled analysis of cohort studies. *International Journal of Cancer*, 107(6), 1001–1011.

Statistics Canada. (2024). Impact of immigration on Canada's population growth 2014–2027. <https://www.canada.ca/en/immigration-refugees-citizenship/corporate/mandate/corporate-initiatives/levels/population-growth-2014-2027.html>

Statistics Canada: <https://www150.statcan.gc.ca/n1/daily-quotidien/220204/dq220204b-eng.htm>

Steele, L. S., Lemieux-Charles, L., Clark, J. P., and Glazier, R. H. (2002). The Impact of Policy Changes on the Health of Recent Immigrants and Refugees in the Inner City: A Qualitative Study of Service Providers' Perspectives. *Canadian Journal of Public Health*, 93(2): 118–122.

Subedi, R. P., and Rosenberg, M. W. (2014). Determinants of the variations in self-reported health status among recent and more established immigrants in Canada. *Social Science and Medicine*, 115: 103–110.

Tergas, A. I., Prigerson, H. G., Shen, M. J., Dinicu, A. I., Neugut, A. I., Wright, J. D., Hershman, D. L., and Maciejewski, P. K. (2022). Association between immigrant status and advanced cancer patients' location and quality of death. *Cancer*, 128(18): 3352–3359.

Terza, J. V., Basu, A., & Rathouz, P. J. (2008). Two-stage residual inclusion estimation: Addressing endogeneity in health econometric modeling. *Journal of Health Economics*, 27(3), 531–543.

Thun, M. J., Linet, M. S., Cerhan, J. R., Haiman, C. A., Schottenfeld, D., EBSCOhost, & EBSCOhost. (2018). Schottenfeld and Fraumeni cancer epidemiology and prevention (M. J. Thun, M. S. Linet, J. R. Cerhan, C. A. Haiman, & D. Schottenfeld, Eds.; Fourth edition.). Oxford University Press.

Tsai, P.-L., & Ghahari, S. (2023). Immigrants' Experience of Health Care Access in Canada: A Recent Scoping Review. *Journal of Immigrant and Minority Health*, 25(3), 712–727.

Urquia M, Walld R, Prior H, Detillieux G, Eze N, Koseva I. (2020). *The Diversity of Immigrants to Manitoba, Migration Dynamics and Basic Healthcare Service Use*. Manitoba Centre for Health Policy.

Vang Z, Sigouin J, Flenon A, Gagnon, A. (2015). *The Healthy Immigrant Effect in Canada: A Systematic Review*. Population Change and Life Course Strategic Knowledge Cluster Discussion Paper Series 2015; 3(1): Article 4.

- Vang, Z. M., Sigouin, J., Flenon, A., & Gagnon, A. (2017). Are immigrants healthier than native-born Canadians? A systematic review of the healthy immigrant effect in Canada. *Ethnicity & Health*, 22(3), 209–241.
- Wanigaratne, S., Cole, D. C., Bassil, K., Hyman, I., Moineddin, R., & Urquia, M. L. (2015). Contribution of HIV to Maternal Morbidity Among Refugee Women in Canada. *American journal of public health*, 105(12), 2449–2456.
- Wanigaratne, S., Shakya, Y., Gagnon, A. J., Cole, D. C., Rashid, M., Blake, J., Dastoori, P., Moineddin, R., Ray, J. G., & Urquia, M. L. (2018). Refugee maternal and perinatal health in Ontario, Canada: a retrospective population-based study. *BMJ Open*, 8(4), Article e018979.
- Woods, R. R., Kliewer, E. V., McGrail, K. M., & Spinelli, J. J. (2019). Breast cancer incidence by country of birth among immigrant women in British Columbia, Canada. *Cancer Epidemiology*, 60, 174–178.
- Yarnell, C. J., Fu, L., Manuel, D., Tanuseputro, P., Stukel, T., Pinto, R., Scales, D. C., Laupacis, A., and Fowler, R. A. (2017). Association Between Immigrant Status and End-of-Life Care in Ontario, Canada. *JAMA*, 318(15): 1479–1488.
- Zimmerman, F. J., & Pronk, N. P. (2025). Socioeconomic milieu and culture: Forcing factors and the most fundamental determinant of health. *Progress in Cardiovascular Diseases*, 90, 62–70.

Appendix IV

Appendix IV.1: Mortality rates among immigrant and non-immigrant cancer patients within three years after diagnosis between 1995 and 2022.

	Person Years	N of death	Rate (per 100)	Unadjusted Odds Ratio	Adjusted Odds Ratio [*]
Immigrants	8289	330	39.81	1.07 (0.94, 1.22)	0.99 (0.86, 1.13)
Non-immigrants	24990	930	37.21	1.00	1.00

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

* Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, and cancer stage at diagnosis.

Appendix IV.2: Unadjusted and adjusted differences in annual health care costs (CA\$) between immigrants and non-immigrants cancer patients by survivors and decedents

Time	Immigrants Unadjusted mean Costs UMC (N)	Non- immigrants Unadjusted mean Costs UMC (N)	Unadjusted mean differences in average annual healthcare costs UMd (95% CI) *	Adjusted mean differences in average annual healthcare costs AMd (95% CI) **	Adjusted mean differences in average annual healthcare costs AMd (95% CI) ***
Survivors					
-2	1869 (3318)	2529 (9946)	-660 (-917, -362)	-1037 (-1411, -622)	-794 (-1101, -452)
-1	2067 (3409)	2816 (10013)	-749 (-1038, -412)	-1203 (-1527, -848)	-835 (-1116, -527)
0	12665 (3409)	11431 (10013)	1234 (569, 1935)	758 (28, 1523)	1259 (603, 1949)
1	9377 (3409)	7947 (10013)	1429 (634, 2298)	701 (-106, 1569)	895 (196, 1653)
2	7518 (3264)	7454 (9679)	64 (-776, 1009)	-491 (-1573, 721)	-103 (-1048, 967)
Deceased					
-2	4249 (835)	4893 (2769)	-643 (-2474, 2571)	-576 (-2514, 2454)	-652 (-2735, 2605)
-1	6062 (879)	5064 (2851)	998 (-1359, 4855)	1328 (-844, 4486)	366 (-1330, 2663)
0	24171 (879)	25456 (2851)	-1285 (-5058, 3185)	1274 (-2428, 5677)	1613 (-2064, 5958)
1	52471 (879)	47842 (2851)	4629 (-11839, 28628)	7850 (-9305, 34062)	7200 (-9554, 32460)
2	134644 (737)	196004 (2447)	-61360 (-114436, 26275)	-25755 (-85053, 66446)	-36127 (-94913, 54644)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, status at last follow-up, and calendar year. *** Adjusted all variables of model ** with 2SRI.

The models incorporated a Generalized Estimating Equations (GEE) model with a log-gamma distribution and a first-order autoregressive (AR 1) within-subject correlation for the hurdle model.

Appendix IV.3: Unadjusted and adjusted odds ratios for healthcare utilization and differences in annual costs for healthcare services stratified by end of follow-up status (died or survivor) for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs non-immigrants.

Time	Unadjusted ORs (95% CI) *	AMDs (95% CI) *	Adjusted ORs (95% CI) **	AMDs (95% CI) **	Adjusted ORs (95% CI) ***	AMDs (95% CI) ***
Inpatient HC						
Among survivors						
-2	0.94 (0.80, 1.10)	-367 (-483, -195)	0.91 (0.77, 1.08)	-190 (-517, 271)	0.91 (0.76, 1.08)	-113 (-323, 180)
-1	0.77 (0.65, 0.90)	-391 (-586, -61)	0.71 (0.60, 0.84)	-622 (-881, -275)	0.71 (0.60, 0.85)	-388 (-555, -164)
0	1.36 (1.27, 1.46)	754 (225, 1334)	1.15 (1.06, 1.25)	756 (27, 1569)	1.15 (1.06, 1.25)	551 (61, 1101)
1	1.04 (0.95, 1.14)	68 (-385, 609)	0.92 (0.83, 1.02)	-356 (-856, 232)	0.93 (0.83, 1.03)	-133 (-471, 265)
2	0.81 (0.72, 0.92)	-302 (-614, 118)	0.71 (0.62, 0.82)	-1068 (-1446, -554)	0.72 (0.63, 0.82)	-701 (-955, -350)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
Among deceased						
-2	0.62 (0.37, 1.02)	103 (-478, 1156)	0.67 (0.40, 1.11)	33 (-508, 1005)	0.74 (0.44, 1.25)	89 (-468, 1088)
-1	0.87 (0.58, 1.31)	247 (-503, 1550)	0.85 (0.55, 1.30)	-157 (-478, 337)	0.96 (0.62, 1.47)	-193 (-477, 231)
0	0.90 (0.69, 1.16)	-146 (-1779, 1772)	0.86 (0.55, 1.34)	120 (-604, 967)	0.93 (0.68, 1.28)	443 (-281, 1289)
1	0.91 (0.70, 1.19)	3754 (-2427, 12932)	0.99 (0.73, 1.33)	1990 (-1659, 8573)	1.07 (0.80, 1.44)	1553 (-1398, 6483)
2	0.95 (0.60, 1.49)	-10828 (-23837, 11210)	1.17 (0.73, 1.87)	653 (-8152, 16747)	1.22 (0.75, 1.97)	179 (-8913, 16697)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
Day Surgery						
survivors						
-2	0.72 (0.63, 0.82)	-43 (-70, -9)	0.68 (0.59, 0.78)	-81 (-110, -45)	0.70 (0.61, 0.81)	-67 (-91, -40)
-1	0.78 (0.69, 0.88)	-47 (-67, -22)	0.73 (0.64, 0.83)	-63 (-90, -31)	0.75 (0.66, 0.85)	-55 (-77, -29)
0	1.12	206	0.99	112	1.00	97

Time	Unadjusted ORs (95% CI) *	AMDs (95% CI) *	Adjusted ORs (95% CI) **	AMDs (95% CI) **	Adjusted ORs (95% CI) ***	AMDs (95% CI) ***
	(1.04, 1.21)	(122, 296)	(0.92, 1.07)	(47, 183)	(0.92, 1.08)	(44, 154)
1	0.95 (0.87, 1.03)	-12 (-60, 41)	0.86 (0.78, 0.94)	-69 (-108, -26)	0.86 (0.79, 0.95)	-59 (-90, -23)
2	0.87 (0.79, 0.97)	-64 (-96, -27)	0.80 (0.72, 0.88)	-71 (-109, -25)	0.81 (0.73, 0.90)	-61 (-92, -23)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
Among deceased						
-2	0.78 (0.52, 1.16)	-56 (-97, 3)	0.76 (0.50, 1.12)	-54 (-98, 10)	0.79 (0.53, 1.19)	-51 (-93, 8)
-1	0.81 (0.56, 1.17)	-39 (-86, 24)	0.76 (0.53, 1.10)	-1.6 (-57, 83)	0.77 (0.53, 1.12)	4 (-53, 85)
0	0.99 (0.77, 1.27)	-72 (-169, 38)	0.96 (0.74, 1.25)	-72 (-135, -0.93)	0.93 (0.71, 1.21)	-64 (-124, 5)
1	1.00 (0.75, 1.33)	-43 (-126, 58)	1.00 (0.74, 1.34)	-45 (-94, 14)	1.01 (0.75, 1.35)	-30 (-77, 28)
2	0.72 (0.45, 1.15)	-37 (-142, 103)	0.67 (0.41, 1.11)	-110 (-146, -67)	0.70 (0.43, 1.15)	-35 (-100, 54)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
Physician Services						
Among survivors						
-2	0.75 (0.66, 0.85)	-96 (-140, -50)	0.73 (0.64, 0.83)	-31 (-83, 24)	0.81 (0.71, 0.93)	-33 (-67, 3)
-1	0.80 (0.69, 0.92)	-96 (-143, -46)	0.79 (0.68, 0.91)	-35 (-92, 25)	0.84 (0.72, 0.97)	-45 (-81, -6)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
Among deceased						
-2	0.61 (0.41, 0.91)	-145 (-262, -9)	0.55 (0.37, 0.83)	-172 (-279, -54)	0.55 (0.36, 0.83)	-33 (-67, 3)
-1	0.89 (0.56, 1.43)	-135 (-235, -24)	0.81 (0.51, 1.30)	-40 (-152, 83)	0.83 (0.51, 1.33)	-45 (-82, -6)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
ED						
Among survivors						
-2	1.03	-1	1.0	-3	1.01	-3

Time	Unadjusted ORs (95% CI) *	AMDs (95% CI) *	Adjusted ORs (95% CI) **	AMDs (95% CI) **	Adjusted ORs (95% CI) ***	AMDs (95% CI) ***
	(0.77, 1.37)	(-5, 4)	(0.74, 1.33)	(-10, 6)	(0.76, 1.35)	(-8, 5.3)
-1	0.98 (0.76, 1.26)	-3 (-6, 2)	0.95 (0.74, 1.22)	3.7 (-5, 17)	0.96 (0.75, 1.25)	3 (-5, 14)
0	1.46 (1.27, 1.67)	8 (-4, 22)	1.40 (1.23, 1.59)	18 (6, 34)	1.43 (1.24, 1.65)	15 (4, 28)
1	1.24 (1.07, 1.43)	-22 (-46, 10)	1.18 (1.03, 1.37)	8 (-5, 26)	1.21 (1.03, 1.41)	8 (-4, 23)
2	1.12 (0.96, 1.29)	-116 (-156, -61)	1.07 (0.92, 1.24)	-24 (-37, -8)	1.09 (0.93, 1.28)	-20 (-32, -6)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
Among deceased						
-2	1.43 (0.13, 15.6)	0.50 (-0.71, 3)	1.41 (0.13, 15.6)	0.40 (-1, 3)	1.52 (0.15, 15.23)	0.43 (-1.05, 3.2)
-1	1.41 (0.26, 7.74)	-2 (-3, 0.10)	1.31 (0.24, 7.23)	0.79 (-1.46, 0.83)	1.36 (0.25, 7.40)	-0.52 (-1.4, 0.9)
0	1.48 (0.97, 2.26)	-10 (-20, 4)	1.51 (0.96, 2.36)	-3.7 (-7.4, 1.9)	1.47 (0.95, 2.26)	-3 (-6, 2)
1	0.89 (0.69, 1.16)	173 (-95, 558)	0.88 (0.67, 1.15)	2.5 (-19, 30)	0.88 (0.69, 1.11)	4.3 (-16, 31)
2	1.50 (1.08, 2.09)	-496 (-1842, 1373)	1.60 (1.13, 2.26)	110 (-14, 311)	1.63 (1.19, 2.24)	131 (4, 333)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
Drug						
Among survivors						
-2	1.24 (1.12, 1.37)	-193 (-263, -97)	1.14 (1.02, 1.27)	-281 (-379, -143)	1.07 (0.96, 1.20)	-283 (-381, -145)
-1	1.37 (1.24, 1.50)	-127 (-198, -34)	1.26 (1.13, 1.40)	-207 (-314, -53)	1.18 (1.06, 1.31)	-200 (-308, -45)
0	1.61 (1.49, 1.73)	193 (12, 415)	1.45 (1.33, 1.58)	-116 (-272, 79)	1.41 (1.29, 1.53)	-106 (-259, 86)
1	1.65 (1.54, 1.78)	1032 (510, 1705)	1.56 (1.43, 1.69)	282 (-27, 672)	1.50 (1.38, 1.62)	254 (-45, 632)
2	1.59 (1.54, 1.78)	1098 (327, 2135)	1.56 (1.43, 1.70)	247 (-230, 889)	1.47 (1.35, 1.59)	296 (-197, 959)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)
Among deceased						
-2	1.40	-154	1.52	-39	1.46	-24

Time	Unadjusted ORs (95% CI) *	AMDs (95% CI) *	Adjusted ORs (95% CI) **	AMDs (95% CI) **	Adjusted ORs (95% CI) ***	AMDs (95% CI) ***
	(1.07, 1.83)	(-415, 269)	(1.14, 2.03)	(-140, 112)	(1.11, 1.92)	(-130, 138)
-1	1.40 (1.07, 1.84)	-160 (-377, 151)	1.34 (1.00, 1.79)	-7 (-112, 150)	1.30 (0.99, 1.72)	8 (-103, 173)
0	1.64 (1.26, 2.14)	461 (-43, 1121)	1.57 (1.17, 2.10)	115 (-19, 285)	1.57 (1.17, 2.11)	112 (-13, 268)
1	1.37 (1.02, 1.85)	1072 (270, 2074)	1.38 (1.00, 1.89)	267 (33, 560)	1.35 (0.98, 1.86)	268 (45, 545)
2	1.37 (0.93, 2.00)	402 (-416, 1448)	1.69 (1.10, 2.59)	283 (-19, 685)	1.40 (0.94, 2.09)	401 (31, 916)
Non-immigrants	1 (ref)	0 (ref)	1 (ref)	0 (ref)	1 (ref)	0 (ref)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, status at last follow-up, and calendar year. *** Adjusted all variables of model **, except status at last follow-up. *** Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a logit model for healthcare utilization, and a Generalized Estimating Equations (GEE) model with a log-gamma distribution for annual healthcare costs. Both GEEs used a first-order autoregressive (AR1) within-subject correlation in the hurdle model.

Appendix IV.4: Unadjusted and adjusted odds ratios for healthcare utilization at Cancer Care Manitoba after diagnosis between 1995 and 2022, comparing immigrants vs non-immigrants.

	Unadjusted odds ratios of healthcare utilization (95% CI) *	Adjusted odds ratios of healthcare utilization (95% CI) ***
Hormone therapy		
Diagnosis to a maximum of 6 years	1.44 (1.31, 1.58)	0.93 (0.81, 1.07)
Radiation therapy		
Diagnosis to a maximum of 6 years	1.33 (1.23, 1.43)	0.87 (0.80, 0.96)
Chemotherapy		
Diagnosis to a maximum of 6 years	1.45 (1.35, 1.56)	0.95 (0.85, 1.05)
Surgery		
Diagnosis to a maximum of 6 years	0.73 (0.67, 0.79)	1.0 (0.89, 1.11)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

*** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, and calendar year. *** Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) approach with a logit model for healthcare utilization. The GEEs employed a first-order autoregressive (AR1) within-subject correlation in the hurdle model.

Appendix IV.5: Unadjusted and adjusted differences in annual health care costs between 1995 and 2022, comparing cancer patient immigrants vs non-immigrants, by sex (p-value of interaction between immigrant*sex=0.70)

Time	Immigrants Unadjusted Mean Costs (UMC) (CA\$)	Non-immigrants Unadjusted Mean Costs (UMC) (CA\$)	Unadjusted mean differences in costs (UMd, 95% CI) *	Adjusted mean differences in costs (AMd, 95% CI) ***
Among Female				
-2	1481	2440	-958 (-794, -31)	-510 (-833, -145)
-1	2034	2836	-802 (-1105, -446)	-702 (-975, -397)
0	13519	12741	778 (-92, 1708)	791 (131, 1490)
1	11891	10386	1505 (-876, 4483)	1049 (-641, 3125)
2	11833	14446	2613 (-4951, 303)	-1281 (-3220, 1125)
Among Male				
-2	2118	3082	-964 (-1419, -384)	-1269 (-1692, -778)
-1	2815	3186	-371 (-1019, 470)	-996 (-1420, -511)
0	13673	12151	1521 (409, 2735)	461 (-394, 1387)
1	13919	11537	2382 (389, 4708)	1005 (-482, 2726)
2	16088	18068	-1981 (-8315, 8466)	1219 (-4139, 9071)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

*** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, and calendar year. ***Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a log-gamma distribution and a first-order autoregressive (AR 1) within-subject correlation for the hurdle model.

Appendix IV.6: Sensitivity Analysis: Without those diagnosed with stage 4 cancer or with nonmelanoma skin cancer

The study performed this sensitivity analysis by excluding those diagnosed with stage 4 and/or non-melanoma skin cancer.

Appendix IV6.1 Patterns of Healthcare Service Use Among Immigrants and Non-Immigrants Before and After Cancer Diagnosis.

Healthcare Services	Immigrants (%)	Non-immigrants (%)	Diff.	P-value of χ^2
Inpatient HC				
Pre-diagnosis years (t<1)				
-2	5.34	5.81	-0.50	0.28
-1	5.34	6.75	-1.40	0.0017
Diagnosis year (t = 0)	44.18	37.42	6.80	<.0001
Post-diagnosis years (t>1)				
1	20.39	19.75	0.60	0.38
2	11.18	13.25	-2.10	0.0010
Day Surgery				
Pre-diagnosis years (t<1)				
-2	7.88	10.93	-3.10	<.0001
-1	9.42	11.93	-2.50	<.0001
Diagnosis year (t = 0)	41.82	39.09	2.70	0.0024
Post-diagnosis years (t>1)				
1	21.23	22.38	-1.20	0.13
2	15.50	17.17	-1.70	0.0176
Physician fees and tests				
Pre-diagnosis years (t<1)				
-2	90.07	92.38	-2.30	<.0001
-1	92.77	93.91	-1.10	0.0112
Diagnosis year (t = 0)	99.95	99.93	0.02	0.62
Post-diagnosis years (t>1)				
1	97.63	98.45	-0.80	0.0007
2	95.92	97.55	-1.60	<.0001
Emergency Department care				
Pre-diagnosis years (t<1)				
-2	1.66	1.59	0.10	0.79
-1	2.14	2.17	-0.03	0.90
Diagnosis year (t = 0)	9.42	6.79	2.60	<.0001
Post-diagnosis years (t>1)				
1	9.26	7.75	1.50	0.0025
2	8.50	7.93	0.60	0.26

Govt. funded drug service				
Pre-diagnosis years (t<1)				
-2	17.87	14.70	3.20	<.0001
-1	19.50	14.96	4.50	<.0001
Diagnosis year (t = 0)	39.83	29.25	10.60	<.0001
Post-diagnosis years (t>1)				
1	43.50	32.53	11.00	<.0001
2	38.34	28.35	10.00	<.0001
Cancer Care Manitoba Services within 5 years after diagnosis				
Hormone therapy	17.33	12.52	4.80	<.0001
Radiation therapy	30.77	25.07	5.70	<.0001
Chemotherapy	31.43	23.88	7.60	<.0001
Surgery	79.41	84.20	-4.8	<.0001

Appendix IV6.2 Mortality rates among immigrant and non-immigrant cancer patients within three years after diagnosis between 1995 and 2022.

	Person Years	N of death	Rate (per 1000)	Unadjusted Odds Ratio	Adjusted Odds Ratio*
Immigrants	7633	238	29.20	1.07 (0.92, 1.24)	1.02 (0.87, 1.19)
Non-immigrants	23556	926	31.18	1.00	1.00

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

* Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, and cancer stage at diagnosis.

Appendix IV6.3 Unadjusted and adjusted differences in annual health care costs for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs. non-immigrants.

Time	Immigrants Unadjusted mean Costs (UMC, CA\$) (Obs)	Non- immigrants Unadjusted mean Costs (UMC, CA\$) (Obs)	Unadjusted mean differences in average annual healthcare costs (UMd, 95% CI) *	Adjusted mean differences in average annual healthcare costs (AMd, 95% CI) **	Adjusted mean differences in average annual healthcare costs (AMd, 95% CI) ***
Pre-diagnosis years (t<0)					
-2	2063 (3805)	2703 (11919)	-640 (-947, -280)	-928 (-1300, -514)	-693 (-942, -419)
-1	2337 (3929)	3043 (12067)	-706 (-1054, -299)	-1044 (-1381, -673)	-769 (-994, -523)
Diagnosis year (t = 0)	12782 (3929)	11852 (12067)	930 (231, 1670)	1112 (400, 1859)	624 (135, 1139)
Post-diagnosis years (t >0)					
1	11028 (3929)	9633 (12067)	1396 (-275, 3362)	698 (-457, 1992)	618 (-494, 1905)
2	10912 (3704)	13459 (11489)	-2547 (-5582, 1657)	-1287 (-3026, 792)	-1015 (-3148, 1725)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, status at last follow-up, and calendar year. *** Adjusted all variables of model **, except status at last follow-up. *** Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a log-gamma distribution and a first-order autoregressive (AR 1) within-subject correlation for the hurdle model.

Appendix IV6.4 Unadjusted and adjusted odds ratios for healthcare utilization and differences in annual healthcare costs by services for cancer patients diagnosed between 1995 and 2022, comparing immigrants vs non-immigrants.

Time	Unadjusted odds ratios of healthcare utilization (95% CI) *	Unadjusted mean differences in average annual healthcare costs (95% CI) *	Adjusted odds ratios of healthcare utilization (95% CI) **	Adjusted mean differences in average annual healthcare costs (95% CI) **	Adjusted odds ratios of healthcare utilization (95% CI) ***	Adjusted mean differences in average annual healthcare costs (95% CI) ***
Inpatient HC						
-2	0.91 (0.77, 1.07)	-262 (-441, 3)	0.89 (0.75, 1.06)	-164 (-479, 268)	0.93 (0.78, 1.09)	-97 (-264, 134)
-1	0.78 (0.67, 0.91)	-334 (-574, 25)	0.73 (0.62, 0.86)	-602 (-859, -261)	0.74 (0.63, 0.87)	-298 (-427, -127)
0	1.32 (1.23, 1.42)	485 (-83, 1105)	1.16 (1.06, 1.26)	938 (282, 1662)	1.16 (1.06, 1.26)	449 (106, 832)
1	1.04 (0.95, 1.14)	711 (-721, 2657)	0.92 (0.84, 1.02)	2 (-745, 945)	0.95 (0.86, 1.05)	88 (-529, 949)
2	0.82 (0.74, 0.92)	-2405 (-4804, 1872)	0.74 (0.65, 0.83)	-930 (-2033, 818)	0.77 (0.68, 0.87)	-540 (-1803, 1772)
Day Surgery						
-2	0.70 (0.61, 0.79)	-47 (-71, -16)	0.66 (0.58, 0.76)	-76 (-103, -44)	0.69 (0.60, 0.79)	-70 (-93, -44)
-1	0.77 (0.68, 0.87)	-51 (-71, -27)	0.72 (0.63, 0.82)	-55 (-80, -26)	0.74 (0.65, 0.83)	-51 (-74, -24)
0	1.12 (1.04, 1.21)	172 (98, 250)	1.00 (0.92, 1.08)	94 (39, 153)	1.00 (0.93, 1.09)	82 (34, 133)
1	0.93 (0.86, 1.01)	-22 (-66, 26)	0.84 (0.77, 0.92)	-65 (-98, -28)	0.85 (0.78, 0.93)	-57 (-86, -25)
2	0.88 (0.80, 0.98)	-54 (-89, -13)	0.81 (0.73, 0.90)	-56 (-93, -14)	0.82 (0.74, 0.92)	-51 (-84, -12)
Physician Services						
-2	0.75 (0.66, 0.85)	-111 (-155, -63)	0.69 (0.61, 0.79)	-133 (-181, -82)	0.76 (0.67, 0.87)	-109 (-149, -67)
-1	0.83 (0.72, 0.96)	-114 (-159, -67)	0.78 (0.67, 0.90)	-119 (-170, -66)	0.82 (0.71, 0.95)	-99 (-141, -55)
0	1.47 (0.32, 6.79)	314 (196, 435)	1.32 (0.30, 5.80)	163 (61, 268)	1.33 (0.30, 5.88)	134 (51, 220)
1	0.65 (0.51, 0.83)	229 (93, 373)	0.61 (0.47, 0.78)	73 (-47, 198)	0.61 (0.47, 0.79)	77 (-25, 184)

2	0.58 (0.48, 0.83)	-167 (-323, 1.2)	0.55 (0.45, 0.69)	-233 (-374, -83)	0.55 (0.45, 0.67)	-176 (-304, -39)
Emergency Department						
-2	1.04 (0.78, 1.39)	-0.56 (-3.8, 4)	1.02 (0.76, 1.37)	-3 (-9, 7)	1.03 (0.77, 1.38)	-1 (-5, 4)
-1	0.98 (0.77, 1.26)	-2.5 (-6, 2)	0.96 (0.75, 1.24)	2 (-6, 14)	0.97 (0.76, 1.25)	0.44 (-4, 7)
0	1.43 (1.26, 1.62)	4 (-6, 16)	1.37 (1.20, 1.57)	13 (2, 26)	1.39 (1.22, 1.59)	5 (-0.8, 13)
1	1.22 (1.07, 1.38)	-13 (-38, 17)	1.16 (1.02, 1.32)	7 (-10, 28)	1.18 (1.03, 1.34)	5 (-7, 20)
2	1.08 (0.94, 1.23)	-117 (-168, -51)	1.04 (0.91, 1.19)	-18 (-73, 73)	1.07 (0.93, 1.23)	-3 (-58, 94)
Govt. Funded Drug						
-2	1.25 (1.15, 1.35)	-178 (-264, -66)	1.15 (1.03, 1.27)	-188 (-266, -82)	1.10 (0.99, 1.22)	-165 (-238, -68)
-1	1.38 (1.27, 1.50)	-146 (-221, -52)	1.26 (1.14, 1.40)	-153 (-239, -37)	1.20 (1.09, 1.33)	-127 (-207, -18)
0	1.60 (1.49, 1.71)	17 (-123, 182)	1.51 (1.38, 1.65)	-95 (-205, 38)	1.44 (1.32, 1.57)	-74 (-173, 46)
1	1.60 (1.49, 1.71)	439 (70, 897)	1.54 (1.42, 1.67)	137 (-71, 390)	1.47 (1.36, 1.60)	131 (-58, 362)
2	1.56 (1.45, 1.68)	210 (-263, 822)	1.53 (1.41, 1.67)	5 (-301, 401)	1.47 (1.35, 1.60)	103 (-233, 555)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, status at last follow-up, and calendar year. *** Adjusted all variables of model **, except status at last follow-up. *** Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a logit model for healthcare utilization, and a Generalized Estimating Equations (GEE) model with a log-gamma distribution for annual healthcare costs. Both GEEs used a first-order autoregressive (AR1) within-subject correlation in the hurdle model.

Appendix IV6.5 Unadjusted and adjusted odds ratios for healthcare utilization at Cancer Care Manitoba after diagnosis between 1995 and 2022, comparing immigrants vs non-immigrants.

	Unadjusted odds ratios of healthcare utilization (95% CI) *	Adjusted odds ratios of healthcare utilization (95% CI) ***
Hormone therapy		
Diagnosis to a maximum of 6 years	1.46 (1.33, 1.61)	0.91 (0.79, 1.06)
Radiation therapy		
Diagnosis to a maximum of 6 years	1.00 (0.94, 1.07)	0.85 (0.77, 0.94)
Chemotherapy		
Diagnosis to a maximum of 6 years	1.04 (0.99, 1.10)	0.96 (0.86, 1.07)
Surgery		
Diagnosis to a maximum of 6 years	0.72 (0.66, 0.79)	0.95 (0.84, 1.08)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

*** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, and calendar year. *** Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) approach with a logit model for healthcare utilization. The GEEs employed a first-order autoregressive (AR1) within-subject correlation in the hurdle model.

Appendix IV6.6 Unadjusted and adjusted differences in annual health care costs between immigrant and non-immigrant cancer patients by survivors and decedents

Time	Immigrants Unadjusted mean Costs UMC (CA\$)	Non- immigrants Unadjusted mean Costs UMC (CA\$)	Unadjusted mean differences in average annual healthcare costs UMd (95% CI) *	Adjusted mean differences in average annual healthcare costs AMd, (95% CI) **	Adjusted mean differences in average annual healthcare costs AMd (95% CI) ***
Among those survive at the last follow-up					
-2	1866	2539	-673 (-938, -363)	-926 (-1282, -530)	-669 (-937, -373)
-1	2064	2863	-798 (-1099, -446)	-1118 (-1427, -780)	-786 (-1028, -522)
0	12077	11032	1045 (384, 1744)	831 (143, 1554)	821 (283, 1385)
1	8254	7401	852 (122, 1653)	301 (-411, 1070)	416 (-144, 1020)
2	6305	7017	-712 (-1425, 92)	-1214 (-2051, -284)	-783 (-1437, -54)
Among those deceased at the last follow-up					
-2	3764	3882	-263 (-2611, 4188)	-256 (-2548, 3569)	-309 (-2834, 3910)
-1	4066	4663	557 (-2135, 5210)	1330 (-1173, 5185)	57 (-1768, 2575)
0	18175	18427	-1707 (-6314, 3979)	311 (-3834, 5481)	257 (-3906, 5374)
1	26004	21367	7195 (-13597, 41297)	5174 (-14232, 40929)	5629 (-14704, 42660)
2	37733	45981	-52345 (-116073, 67481)	-9259 (-65269, 86472)	-17280 (-76552, 84037)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, status at last follow-up, and calendar year. *** Adjusted all variables of model ** with 2SRI.

The models incorporated a Generalized Estimating Equations (GEE) model with a log-gamma distribution and a first-order autoregressive (AR 1) within-subject correlation for the hurdle model.

Appendix IV 6.7 Unadjusted and adjusted differences in annual health care costs between immigrant and non-immigrant cancer patients by sex (p-value of interaction between immigrant*sex=0.89)

Time	Immigrants Unadjusted mean Costs (UMC) (CA\$)	Non-immigrants Unadjusted mean Costs (UMC) (CA\$)	Unadjusted mean differences in average annual healthcare costs (UMd, 95% CI) *	Adjusted mean differences in average annual healthcare costs (AMd, 95% CI) ***
Among Female				
-2	2021	2479	-458 (-824, -12)	-411 (-701, -81)
-1	2034	2897	-863 (-1176, -493)	-588 (-830, -319)
0	12873	12180	693 (-175, 1625)	795 (206, 1422)
1	10416	9301	1115 (-1324, 4300)	702 (-720, 2466)
2	8956	12347	-3391 (-5270, -1014)	-1648 (-2936, -71)
Among Male				
-2	2117	3009	-893 (-1386, -375)	-1169 (-1572, -699)
-1	2747	3241	-494 (-1037, 478)	-973 (-1379, -506)
0	12668	11424	1244 (117, 2481)	361 (-453, 1246)
1	11868	10086	1782 (-41, 3936)	346 (-915, 1813)
2	13820	15194	-1374 (-7635, 10076)	1153 (-3682, 8640)

Matching between immigrants and non-immigrants was conducted by the time of diagnosis, age at the time of cancer diagnosis, sex, and region of residence (Urban/Rural) at the time of cancer diagnosis.

*** Adjusted for age at cancer diagnosis, marital status, employment/income assistance, rent assistance, neighbourhood income quintiles, Elixhauser comorbidity index, cancer type, cancer stage at diagnosis, and calendar year. *** Model used 2SRI with IPCW for the probabilities of being uncensored.

The models incorporated a Generalized Estimating Equations (GEE) model with a log-gamma distribution and a first-order autoregressive (AR 1) within-subject correlation for the hurdle model.

CHAPTER 5

GENERAL DISCUSSION

This series of studies contribute to an understanding of a paradox concerning the health dynamics of immigrants in Canada. It underscores that although immigrants typically have health advantages upon arrival and during their first decade in Canada, their challenges integrating into the Canadian society and healthcare system result in a marked increase in the use of acute and emergency department services later in life, thus driving up health care costs, particularly during health crises or near the end-of-life.

5.1 Healthy migrant effects: patterns and trends of healthcare use and costs

The first chapter confirmed the well-documented healthy migrant effect, showing that immigrants generally had a lower mortality risk than non-immigrants. The EOL cost analysis in the second chapter revealed an apparent contradiction with the healthy migrant effect. The study revealed that immigrants had significantly higher healthcare costs in the last year of life. The differences in EOL healthcare costs between immigrants and non-immigrants mainly stem from inpatient care for those who died in hospitals, those with more comorbidities, and high-cost patients. Chapter 3 provides insights into the apparent paradox. It reveals that immigrants used less healthcare and had lower overall healthcare costs in most of the follow-up years after arriving and before the year of death. However, in the year of death, immigrants had significantly higher healthcare costs and used more inpatient and emergency care. These findings on healthcare use and costs among immigrants reveal significant disparities in access to healthcare compared to non-immigrants. This limited access in healthcare among immigrants may

contribute to the accumulation of comorbidities and the exacerbation of the health issues. Consequently, these factors may necessitate more intensive care at EOL. In addition, among older adults, unadjusted annual healthcare costs among immigrants were substantially lower, but after adjusting for unobserved factors, the annual healthcare costs of older adult immigrants converged with those of non-immigrants. The healthcare use and cost pattern analysis among cancer patients in chapter 4 revealed that, before cancer diagnosis, immigrants had lower annual healthcare costs and lower utilization of physician care and inpatient care than non-immigrants but had higher costs than non-immigrants in the year of diagnosis and higher inpatient care utilization, and this pattern was more pronounced among recent immigrants. However, this trend might be misleading among older adults, as lower healthcare use and costs did not necessarily indicate better health or fewer diseases in the years after immigration. Instead, the lower healthcare utilization among older adult immigrants might be due to barriers to integrating the healthcare system and delayed access.

This pattern changed when hidden health factors related to pre-immigration characteristics and circumstances, as well as post-immigration unobserved challenges, were considered using two-stage residual inclusion models for unobserved confounding. Contemporary studies indicate that, although immigrants arrive in Canada with better health and lower mortality risk than their Canadian-born counterparts (Debbarman et al., 2023; Lu and Ng, 2019; Vang et al., 2016), their lower healthcare utilization compared to non-immigrants was not attributable to this initial health advantage. Instead, it resulted from barriers to accessing the healthcare system (Dervic et al., 2025).

5.2 The routine healthcare deficit and crisis-driven healthcare

One of the most consistent findings across chapters 2, 3, and 4 is that immigrants often used fewer healthcare services before, but their healthcare use and costs increased after a cancer diagnosis and/or in the last year of life. The chapters revealed that before a cancer diagnosis, immigrants were less likely to visit physicians, be admitted to a hospital, or undergo day surgeries, and they had lower overall healthcare costs. Chapter 2 showed that a substantially higher proportion of immigrants used inpatient hospital care and emergency department care in the last year of life. Chapter 3 indicates that immigrants were less likely to visit physicians, be admitted to a hospital, or undergo day surgery in nearly all years of follow-up leading up to death, while in the year of death, immigrants were more likely to use inpatient care and emergency department care. Chapter 4 indicated that immigrants were less likely than non-immigrants to visit a physician, be admitted to a hospital, undergo day surgery, or utilize emergency department services prior to a cancer diagnosis. However, once diagnosed with cancer, they experienced an increase in emergency department visits and hospitalizations.

These observed shifts from lower healthcare utilization prior to health issues or EOL to higher acute healthcare use during health crises, or EOL, suggest delayed diagnosis and treatment. These findings indicate that immigrants might miss the preventive window to address their health care needs because they visit primary care physicians less often, leading to later detection or poor management of chronic diseases. As a result, a significant spike in costs occurred when they accessed the highest-cost points in the healthcare system: acute inpatient beds. A study in Canada found that immigrants faced unmet healthcare needs due to communication, cultural, and socioeconomic barriers (Tsai and Ghahari, 2023). Another study in Saskatchewan, Canada, identified challenges immigrants face in accessing and integrating into

the healthcare system, including personal barriers such as communication skills, childcare, and transportation, as well as systemic barriers such as long wait times (Pandey et al., 2021). Moreover, immigrants were less likely to visit primary care, specialists, or the emergency department in the year prior to emergency general surgery (Guo et al., 2026).

Consequently, immigrants were less likely to be diagnosed early with chronic diseases (Harvey-Sullivan et al., 2025; Iqbal et al., 2017) and faced a higher risk of avoidable hospitalizations (Allegri et al., 2022), reflecting their reduced access to preventive care.

5.3 Heterogeneity in the healthcare system integration

Chapter 2 showed that recent immigrants incurred significantly higher end-of-life healthcare costs. The forward analysis presented in Chapter 3 revealed that older adult immigrants utilized significantly less inpatient care and were less likely to undergo day surgery compared to non-immigrants. Additionally, their overall healthcare costs were lower. However, after accounting for unobserved confounding factors, it was found that they incurred higher costs and were more likely to visit physicians and receive government-funded medications. The results indicate that older adult immigrants might have less access to healthcare services based on their health conditions compared to non-immigrants. In Chapter 4, recent immigrants had the lowest pre-cancer care costs and fewer physician visits, yet they relied more on emergency departments and hospitalizations post-diagnosis, leading to higher healthcare expenses. These findings indicate that recent and older adult immigrants may have faced barriers to integration into the Canadian health system. Some research showed that older adult immigrants generally used fewer healthcare services (Di Giuseppe et al., 2024), mainly due to language, cultural, health literacy, health beliefs, and structural barriers (Wang et al., 2019). Furthermore, a study in Canada found

that recent immigrants were less likely to have a regular doctor than those who had been here for 10 years or more (Ravichandiran et al., 2022).

5.4 Contributions to the literature

The *methodological contribution* of this series of studies is that it moved from traditional cross-sectional, static, and perception-based health studies. By utilizing linked administrative datasets (15 datasets) for the long-follow-up cohorts and longitudinal designs, advanced analytical models were used to analyze immigrants' health, healthcare utilization patterns, and associated costs from the onset of their healthcare coverage to the end-of-life.

The *conceptual contribution* of this study is that it shifted the focus from the question, “Do immigrants use and incur healthcare costs more or less?” to a more detailed inquiry: “When and which specific sub-groups of immigrants access healthcare services at different rates, and what is the resulting impact on healthcare use and costs?”

5.5 Policy and practical implications

- 1) Recent immigrants and older adults often experience limited access to physicians before a health issue arises, leading to increased visits to emergency departments and higher hospitalization rates during health crises. Thus, policies may not only ensure immigrants have access to a family physician but also promote health education on how to navigate and utilize the Canadian health system. Additionally, providing information on how to access a language interpreter to newcomers may improve their integration into the Canadian healthcare system.
- 2) Since immigrants are more likely to use inpatient hospital care at the end-of-life and to die in hospital, greater focus on educating patients and family members about palliative

care based on their health condition may help reduce reliance on more aggressive treatments.

- 3) Since immigrants are more likely to use government-funded home care and less likely to access long-term care, and immigrants who stayed at LTC had lower hospitalization rates, policy could focus on a culturally integrated LTC program to reduce hospitalizations and hospital deaths.

5.6 Future research directions

- 1) Qualitative studies and surveys can be done to understand the reasons underlying immigrants' health care decision-making over time and what factors are associated with greater routine use of healthcare services vs delayed emergency care.
- 2) Linking national longitudinal administrative datasets (hospitalizations and deaths) with longitudinal surveys, such as the Longitudinal Survey of Immigrants to Canada (LSIC), and/or Survey on Health Care Access and Experiences - Primary and Specialist Care (SHCAE-PSC) might yield valuable insights into the relations between language proficiency, health literacy, barriers to access, and experiences of discrimination with morbidity and mortality. Such methodology may help assess whether disparities in healthcare utilization between immigrants and non-immigrants stem from differences in healthcare needs, obstacles to accessing care, or challenges in navigating the healthcare system. It may also allow assessment of how these associations evolve over time, particularly in relation to years since immigration.

5.7 References

- Alicia Adserà. (2013). *Fertility of Recent Immigrants to Canada*. IZA - Institute of Labor Economics.
- Allegri, C., Banks, H., & Devillanova, C. (2022). Avoidable hospitalizations and access to primary care: comparisons among Italians, resident immigrants and undocumented immigrants in administrative hospital discharge records. *EClinicalMedicine*, 46, Article 101345.
- Debbarman, S., Prior, H., Walld, R., & Urquia, M. L. (2023). Assessing the migrant mortality advantage among foreign-born and interprovincial migrants in Manitoba, Canada. *Canadian Journal of Public Health*, 114(3), 441–452.
- Dervić, E., Ali, O., Deischinger, C., Prieto-Curiel, R., Stütz, R., Mittendorfer-Rutz, E., & Klimek, P. (2025). Healthcare utilization patterns among migrant populations: Increased readmissions suggest poorer access. A population-wide retrospective cohort study. *Journal of Migration and Health (Online)*, 12, Article 100340.
- Di Giuseppe, G., Sutradhar, R., Pequeno, P., Kwan, M. L., Miglioretti, D. L., Smith-Bindman, R., & Pole, J. D. (2024). Medical imaging utilization in migrants compared with non-migrants in a universal healthcare system: A population-based matched cohort study. *PLoS Medicine*, 21(10), Article e1004474.
- Guo, M., Mourad, N., Karimuddin, A., & Sutherland, J. (2026). Comparing Preoperative Healthcare Utilization Between Immigrants and Non-Immigrants Undergoing Emergency General Surgery in British Columbia. *Journal of Immigrant and Minority Health*.
- Harvey-Sullivan, A., Ali, S., Dhesi, P., Hart, J., Painter, H., Walter, F. M., Funston, G., & Zenner, D. (2025). Comparing cancer stage at diagnosis between migrants and non-migrants: a meta-analysis: Epidemiology. *British Journal of Cancer*, 132(2), Article 100505.
- Iqbal, J., Ginsburg, O., Fischer, H. D., Austin, P. C., Creatore, M. I., Narod, S. A., & Rochon, P. A. (2017). A Population-Based Cross-Sectional Study Comparing Breast Cancer Stage at Diagnosis between Immigrant and Canadian-Born Women in Ontario. *The Breast Journal*, 23(5), 525–536.
- Lu, C., & Ng, E. (2019). Healthy immigrant effect by immigrant category in Canada. *Health Reports*, 30(4), 3–11.
- Pandey, M., Kamrul, R., Michaels, C. R., & McCarron, M. (2022). Identifying Barriers to Healthcare Access for New Immigrants: A Qualitative Study in Regina, Saskatchewan, Canada. *Journal of Immigrant and Minority Health*, 24(1), 188–198.
- Ravichandiran, N., Mathews, M., & Ryan, B. L. (2022). Utilization of healthcare by immigrants in Canada: a cross-sectional analysis of the Canadian Community Health Survey. *BMC Family Practice*, 23(1), Article 69.

Tsai, P.-L., & Ghahari, S. (2023). Immigrants' Experience of Health Care Access in Canada: A Recent Scoping Review. *Journal of Immigrant and Minority Health*, 25(3), 712–727.

Vang, Z. M., Sigouin, J., Flenon, A., & Gagnon, A. (2017). Are immigrants healthier than native born Canadians? A systematic review of the healthy immigrant effect in Canada. *Ethnicity & Health*, 22(3), 209–241.

Wang, L., Guruge, S., & Montana, G. (2019). Older Immigrants' Access to Primary Health Care in Canada: A Scoping Review. *Canadian Journal on Aging*, 38(2), 193–209.