



# Risk of Developing Multimorbidity among Previously Healthy Immigrants and Long-term Ontario Residents

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## Abstract:

**Background:** Multimorbidity is an important health issue associated with a greater risk of adverse health outcomes, more frequent hospitalizations, greater healthcare needs, and premature death. This study examined patterns of and the risk of developing multimorbidity between immigrants and long-term residents of Ontario.

**Methods:** We used a 1:1 matched retrospective observational open cohort design from 1995 to 2016, using routinely collected population-based administrative data at ICES. Multimorbidity was defined as two or more and three or more co-occurring chronic conditions. Chronic disease frequencies of dyads and triads were examined. Stratified multivariate Cox Proportional Hazard models examined the risk of developing multimorbidity and further by world regions of origin for immigrants compared to long-term residents.

**Results:** Hypertension and diabetes, in combination with chronic obstructive pulmonary disease, were the leading multimorbidity dyad and triad groups. After controlling for age, sex, and neighborhood income quintiles, immigrants from the Caribbean and South Asia had a greater risk of developing 2+ multimorbidity, compared to long-term residents. Refugees from North Africa and the Middle East (HR = 1.22 [95% CI: 1.03-1.42]) as well as refugees (HR = 1.78 [95% CI: 1.59 - 1.98]) and family immigrants from South Asia (HR: 1.08 [95% CI: 1.02-1.14]), had a higher risk of 3+ multimorbidity compared to long-term residents of Ontario.

**Conclusion:** These findings highlight the importance of routine population-based data collection on immigration status and world regions of origin to inform public health research. Investments in preventive health services and management of multimorbidity are needed for specific population groups.

**Keyword:** Immigrant health, Multimorbidity, Hypertension and diabetes, Open cohort design, Chronic conditions, Cox proportional hazard models.

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## 1. INTRODUCTION

### 1.1. Background

Multimorbidity, defined as having two or more chronic conditions [1], has been used as a general measure of health status [2], and is a significant public health issue linked to adverse outcomes, frequent hospitalizations, increased healthcare needs, and premature death [1, 3-7].

The global prevalence of multimorbidity is rising due to aging populations, increased life expectancy, and higher rates of chronic conditions such as hypertension, diabetes, and cardiovascular disease [8-10].

In Canada, estimates of multimorbidity vary due to differences in definitions, study designs, and data sources [1, 7]. For instance, the 2011 Canadian Community Health Survey (CCHS) reported that 13% of Canadians aged 20 years and older had two or more chronic diseases [6].

Another study using the Canadian Chronic Disease Surveillance System found that among Canadians aged 40 and over, the prevalence of two or more chronic conditions was 26.5% in 2011/2012 [11]. In Ontario, a population-based study indicated that 1-in-4 Ontarians had two or more chronic conditions, with a significant increase from 2003 to 2009 [5]. Multimorbidity has also been found to be more prevalent at the time of death, particularly among those in low-income neighborhoods [12].

### 1.2. Multimorbidity and Immigrant Health

Canada's immigrant population is growing, with immigrants making up 23% of the population in 2021, a figure projected to rise to 29.1-34% by 2041 [13]. Immigrants enter Canada under three major categories: Economic (a business class visa or those who bring in needed skills), Family (spouses, common-law partners, or immediate family members), and Refugees (government or private sponsored individuals recognized as United Nation Convention refugees prior to entering Canada) [14, 15]<sup>1</sup>. While the "healthy immigrant effect" suggests that immigrants initially have better health than non-immigrants, their health tends to decline over time, becoming similar to or worse than that of non-immigrants [16-20]. However, this effect varies among different immigrant groups [21-23], influenced by factors such as country of origin and their admission category [24-29]. Certain chronic conditions, such as diabetes and cardiovascular disease, are also more prevalent among

immigrants from specific ethnicities and world regions [25, 30-32]. Pre-migration factors and post-settlement barriers, such as access to healthcare, language, and acculturation, contribute to the elevated disease risk over time [33, 34].

Research on multimorbidity among immigrant populations in Canada is limited, with no longitudinal studies examining its incidence or the migration factors associated with this risk compared to the general population.

The objective of this study was to estimate and compare the risk of multimorbidity between disease-free immigrant groups and long-term Ontario residents (LTOR) and to describe patterns of multimorbidity.

## 2. METHODS

### 2.1. Ethics

Ethics approval was obtained from the University of Ottawa Health Science and Science Research and Ethics Board (ethics certificate number: H02-17-20). This study used de-identified population-based health administrative data at ICES. ICES is an independent, non-profit research institute funded by an annual grant from the Ontario Ministry of Health and Ministry of Long-Term Care (MOH and MLTC). As a prescribed entity under Ontario's privacy legislation, ICES is authorized to collect and use health care data for the purposes of health system analysis, evaluation, and decision support. Secure access to these data is governed by policies and procedures that are approved by the Information and Privacy Commissioner of Ontario.

### 2.2. Study Design, Setting and Data Sources

This study used a matched retrospective observational cohort design covering 1995 to 2016 using routinely collected administrative data. We used an open cohort design, where immigrants entered the study at different points in time. The project consisted of analyses from several linked databases using unique encoded identifiers and analyzed at ICES. The Registered Persons Database (RPDB) and The Immigrant and Refugees Citizenship Canada Permanent Residents Database (IRCC) were used to identify LTOR and immigrants, respectively. The Ontario Health Insurance Plan Billing Data (OHIP) was used to identify immigrants and long-term residents who have had an interaction with the healthcare system. We used Census data and Postal Code Conversion Files

(PCCF+) to classify sociodemographic status and geographic area of residence based on urban and rural geographic areas. Our study included nine ICES-derived disease cohorts to capture diagnoses of chronic conditions defined from previously validated, population-derived ICES cohorts [35]. These chronic conditions include asthma [36, 37], congestive heart failure (CHF) [38], chronic obstructive pulmonary disease (COPD) [39], hypertension [40, 41], Crohn's disease and colitis [42, 43], diabetes [44, 45], myocardial infarction [46], rheumatoid arthritis [47, 48], and cancer [49].

### 2.3. Eligibility Criteria

We identified immigrants from the IRCC who met the following criteria: they landed in Ontario between 1992 and 2010 under one of the three major admission categories (refugee, family or economic), were 18 to 70 years of age on December 31 of the year of their landing; remained in Ontario for at least three years and obtained OHIP coverage during that period; and had nodocumentation of any of the nine chronic conditions in the ICES-derived disease cohort data at the end of those 3 years [2]. We excluded immigrants who were classified as

<sup>1</sup>Collectively, these admission categories are defined as landed immigrants. In this paper, to "immigrants" refers to the broad immigrant population that includes all three major admission categories.

"other" in their admission category (<3%). Immigrants entered the cohort at the end of their three-year follow-up an Index date which ranged from 1995-2013. The study outcome evaluation period ended on December 31, 2016.

We identified all LTOR eligible for universal health coverage in the province using the RPDB. The LTOR must have been Ontario residents for at least ten years prior to entering the study, be free of any of the nine chronic conditions, and not have been in the IRCC database at any time since its inception in 1985 [3].

We matched 1:1 eligible immigrants and LTOR based on age, (same year of birth), sex and rurality (Rurality Index Ontario<sup>2</sup> [yes/no] > 45 from the RPDB and PCCF+. Individuals in the matched cohort were linked to the other ICES datasets for analyses.

### 2.4. Variables

#### 2.4.1. Outcome Variables

Our primary outcome examined multimorbidity as Two or more (2+) and Three or more (3+) co-occurring chronic conditions using individuals with no chronic condition as the reference group. We examined multimorbidity using the nine chronic health conditions that were available from the ICES derived disease cohorts [50].

#### 2.4.2. Independent Variables

Our study contained both socio-demographic and immigration variables that were available from linking multiple datasets at ICES. We examined whether an individual was an immigrant (yes/no) belonging to one of the three immigrant categories (refugee, family, or economic immigrant as our primary covariate.

The sociodemographic variables included age (cate-

gorized as 18-29, 30-44, 45+), sex (Male/Female) and neighborhood level income quintiles since individual-level data was not available for income.

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

We derived a world region of origin variable using country of birth data and grouped them into world regions of origin to obtain the following categories: the Caribbean, East Asia and the Pacific, South Asia, Eastern Europe and Central Asia, North Africa and the Middle East, Latin America, Western Europe and the US, and sub-Saharan Africa. This is a method we have used previously [51] and has been applied in other studies using ICES data [32, 52-55].

### 2.5. Statistical Methods

#### 2.5.1. Descriptive Analysis

We examined the presence of chronic conditions among immigrant categories and LTOR, and estimated the prevalence of individual conditions, dyads (2+ chronic conditions), and triads (3+ chronic conditions) in each group.

#### 2.5.2. Overall Estimate of Risk

We calculated the number of chronic conditions for each immigrant (admission) category and for LTOR from their index date until the last follow-up (event, death, loss of OHIP eligibility, or end of the study observation period) and estimated the risk of having at least 1 condition, 2+ and 3+ multimorbidity for each immigrant category and LTOR. We calculated the incidence of having a single condition as a comparison to those with multimorbidity.

We then derived the relative risk for each immigrant visa category compared to LTOR overall and across sociodemographic groups (age, sex, neighborhood income quintiles) and migration profile (world regions of origin, education, and language proficiency upon landing).

#### 2.5.3. Regression Modelling

We used Cox Proportional Hazard Models to determine the hazard ratio for developing multimorbidity over time. We built three stratified multivariate models by immigrant category (refugee, family, economic class immigrants) to estimate the Hazard Ratio (HR) and 95% Confidence Intervals (CI) of multimorbidity risk (2+ and 3+ multimorbidity). The models were adjusted by age, sex, and neighborhood-level income quintiles. Using the same stratified models, we then added an interaction term for immigrant status and world regions of origin to estimate

<sup>2</sup>The Rurality Index Ontario (RIO) is a tool used to measure how rural or urban different areas in Ontario are. It helps to understand and compare the characteristics of various communities across the province.

the risk for immigrants by their world region of origin when compared to LTOR. All analyses were conducted with SAS software, version 9.4 [56].

**3. RESULTS**

Between 1992 and 2010, 2,037,657 immigrants were identified from the IRCC database, of whom 1,156,122 were eligible. Among 9,815,198 eligible LTOR, 1,156,122 were matched to each eligible immigrant. A previous paper provides a complete description of participants and the immigrant and LTOR cohort creation (reference - under review).

**3.1. Descriptive Data**

The distribution of having two or more and three or more co-occurring chronic conditions for each immigrant category and LTOR at last follow-up is summarized in Table 1. The total follow-up period was 13,636,763 years and 13,548,084 years in the immigrant and LTOR groups respectively. The proportion of immigrants with two or more chronic conditions was 8.4% for refugees, 8.1% for

families, and 5.4% for economic immigrants. Economic immigrants (0.9%) had the lowest prevalence of having three or more co-occurring conditions compared to other immigrant categories and LTOR.

Table 2 displays the top ten disease dyads for each immigrant category and LTOR. Hypertension and diabetes accounted for the most prevalent disease dyad for all immigrant categories and LTOR. Among immigrants, asthma and hypertension were the second most prevalent disease dyads. Except for asthma and hypertension, the proportion of all other disease dyads was higher among LTOR compared to immigrants across all categories. The most common disease triad was hypertension COPD for all groups (Table 3) and was highest among LTOR (24.8%) followed by refugees (23.3%). The prevalence of hypertension, diabetes and MI was highest among economic immigrants (12.8%) and refugees (12.3%); whereas CHF, COPD and hypertension were the most prevalent triad among LTOR (12.3%) compared to family (8.8%), refugees (4.7%) and economic immigrants (3.6%).

**Table 1. Distribution of multimorbidity (n, %) for immigrant categories and LTOR.**

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

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

**Table 2. Top 10 disease dyads (n, %).**

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

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

**Table 3. Top 5 disease triads (n, %).**

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

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

**Table 4. Unadjusted relative risk (RR) of multimorbidity (1+, 2+ and 3+ diseases co-occurring) and 95% Confidence Intervals for Immigrant Categories compared to LTOR per 1000 person-years follow up.**

Immigrant Categories																		
-	Refugees						Family						Economic					
-	Multimorbidity Incidence						Multimorbidity Incidence						Multimorbidity Incidence					
-	1+		2+		3+		1+		2+		3+		1+		2+		3+	
-	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.	RR	95% C.I.
<b>Overall</b>	1.25	(1.24–1.26)	1.36	(1.32–1.40)	1.19	(1.13–1.26)	1.00	(0.99–1.01)	1.00	(0.99–1.02)	0.82	(0.79–0.84)	0.90	(0.89–0.91)	0.87	(0.86–0.88)	0.67	(0.64–0.69)
<b>Sex</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Males	1.24	(1.22–1.26)	1.34	(1.29–1.39)	1.14	(1.07–1.23)	1.04	(1.03–1.05)	1.00	(0.98–1.02)	0.82	(0.79–0.86)	0.90	(0.89–0.91)	0.85	(0.84–0.87)	0.67	(0.64–0.70)
Females	1.28	(1.25–1.31)	1.41	(1.33–1.47)	1.27	(1.16–1.40)	1.01	(0.99–1.02)	1.00	(0.98–1.03)	0.81	(0.78–0.85)	0.91	(0.90–0.92)	0.89	(0.87–0.91)	0.67	(0.63–0.70)
<b>Age Categories (baseline)</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
18-29	1.23	(1.19–1.27)	1.45	(1.33–1.57)	1.51	(1.21–1.84)	1.19	(1.17–1.21)	1.26	(1.20–1.31)	1.01	(0.89–1.15)	0.88	(0.86–0.90)	0.89	(0.83–0.95)	0.70	(0.58–0.84)
30-44	1.27	(1.23–1.29)	1.36	(1.31–1.41)	1.16	(1.07–1.25)	1.10	(1.08–1.12)	1.18	(1.14–1.21)	0.98	(0.92–1.05)	0.92	(0.91–0.93)	0.90	(0.88–0.91)	0.69	(0.66–0.72)
45+	1.30	(1.26–1.34)	1.36	(1.30–1.42)	1.17	(1.07–1.27)	0.87	(0.86–0.88)	0.90	(0.88–0.91)	0.77	(0.74–0.80)	0.86	(0.85–0.87)	0.82	(0.80–0.84)	0.64	(0.61–0.67)
<b>Income Quintiles</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Q1 (lowest income)	1.31	(1.28–1.34)	1.43	(1.38–1.48)	1.21	(1.12–1.30)	1.15	(1.13–1.17)	1.20	(1.17–1.23)	1.05	(1.00–1.11)	1.01	(1.00–1.03)	1.04	(1.01–1.06)	0.83	(0.78–0.88)
Q2	1.26	(1.22–1.30)	1.34	(1.26–1.42)	1.13	(1.00–1.28)	1.03	(1.02–1.04)	1.04	(1.01–1.07)	0.84	(0.79–0.89)	0.94	(0.92–0.96)	0.91	(0.88–0.94)	0.74	(0.69–0.80)
Q3	1.23	(1.19–1.27)	1.36	(1.25–1.47)	1.36	(1.13–1.60)	0.98	(0.96–1.00)	0.96	(0.93–1.00)	0.74	(0.69–0.79)	0.89	(0.88–0.90)	0.85	(0.82–0.88)	0.63	(0.58–0.68)
Q4	1.15	(1.09–1.21)	1.19	(1.06–1.32)	1.06	(0.80–1.33)	0.90	(0.88–0.92)	0.84	(0.81–0.87)	0.68	(0.62–0.73)	0.84	(0.83–0.85)	0.77	(0.74–0.80)	0.55	(0.51–0.61)
Q5	1.09	(1.02–1.16)	1.16	(1.01–1.33)	1.04	(0.70–1.39)	0.75	(0.73–0.77)	0.67	(0.63–0.70)	0.49	(0.44–0.54)	0.72	(0.70–0.74)	0.61	(0.59–0.64)	0.44	(0.40–0.48)
<b>Educational Level at Landing</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Secondary or Less	1.34	(1.31–1.37)	1.52	(1.46–1.57)	1.39	(1.29–1.50)	1.05	(1.04–1.06)	1.04	(1.02–1.06)	0.85	(0.82–0.87)	0.98	(0.96–1.00)	0.98	(0.95–1.01)	0.76	(0.71–0.81)
Non-University Qualifications/ Some University	1.19	(1.16–1.22)	1.24	(1.19–1.31)	1.06	(0.95–1.17)	1.01	(0.99–1.03)	0.96	(0.93–0.99)	0.78	(0.72–0.83)	0.93	(0.92–0.94)	0.88	(0.86–0.91)	0.70	(0.65–0.74)
University Degree or Higher	1.09	(1.05–1.13)	1.10	(1.02–1.18)	0.83	(0.71–0.96)	0.95	(0.93–0.97)	0.90	(0.87–0.94)	0.70	(0.64–0.77)	0.87	(0.86–0.88)	0.81	(0.80–0.83)	0.60	(0.56–0.63)
<b>World Region of Origin</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caribbean	1.26	(1.08–1.44)	1.29	(0.98–1.61)	1.34	(0.75–1.94)	1.29	(1.25–1.33)	1.31	(1.25–1.38)	1.07	(0.96–1.19)	1.33	(1.28–1.38)	1.44	(1.33–1.55)	1.16	(0.99–1.36)



Immigrant Categories																		
-	Refugees						Family						Economic					
-	Multimorbidity Incidence						Multimorbidity Incidence						Multimorbidity Incidence					
East Asia & the Pacific	1.02	(0.97–1.07)	0.94	(0.85–1.05)	0.64	(0.51–0.81)	0.83	(0.82–0.84)	0.77	(0.75–0.80)	0.58	(0.55–0.62)	0.78	(0.77–0.79)	0.67	(0.66–0.69)	0.45	(0.42–0.47)
Eastern Europe & Central Asia	0.98	(0.95–1.01)	0.94	(0.88–0.99)	0.80	(0.71–0.90)	0.85	(0.83–0.87)	0.80	(0.76–0.84)	0.72	(0.66–0.80)	0.82	(0.81–0.83)	0.72	(0.69–0.75)	0.64	(0.59–0.70)
Latin America & Mexico	0.97	(0.92–1.02)	0.88	(0.79–0.97)	0.66	(0.53–0.81)	1.07	(1.04–1.10)	1.18	(1.12–1.25)	0.96	(0.86–1.07)	0.83	(0.80–0.86)	0.87	(0.80–0.95)	0.77	(0.65–0.92)
North Africa & the Middle East	1.13	(1.08–1.18)	1.24	(1.15–1.33)	1.35	(1.16–1.57)	0.92	(0.90–0.94)	0.92	(0.85–0.98)	0.79	(0.69–0.90)	0.81	(0.79–0.83)	0.81	(0.77–0.85)	0.76	(0.68–0.85)
South Asia	1.78	(1.74–1.82)	2.21	(2.10–2.32)	1.99	(1.79–2.20)	1.33	(1.31–1.35)	1.38	(1.34–1.43)	1.17	(1.11–1.24)	1.27	(1.25–1.29)	1.46	(1.41–1.50)	1.14	(1.06–1.22)
Sub-Saharan Africa	1.29	(1.24–1.34)	1.33	(1.25–1.43)	1.14	(0.96–1.33)	1.18	(1.13–1.23)	1.05	(0.97–1.14)	0.83	(0.69–0.98)	1.01	(0.97–1.05)	0.90	(0.82–0.98)	0.71	(0.59–0.85)
Western Europe & US	1.15	(0.87–1.43)	1.79	(1.16–2.43)	1.74	(0.76–2.73)	0.72	(0.69–0.75)	0.71	(0.67–0.76)	0.70	(0.62–0.79)	0.61	(0.59–0.63)	0.52	(0.49–0.56)	0.44	(0.38–0.51)
<b>Language Proficiency on Landing</b>	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
None	1.19	(1.16–1.22)	1.32	(1.26–1.38)	1.14	(1.04–1.25)	0.99	(0.98–1.00)	0.95	(0.93–0.97)	0.76	(0.73–0.79)	0.80	(0.79–0.81)	0.72	(0.70–0.74)	0.54	(0.50–0.59)
English, French or Both	1.29	(1.26–1.31)	1.39	(1.34–1.44)	1.21	(1.12–1.31)	1.05	(1.04–1.06)	1.07	(1.05–1.10)	0.91	(0.86–0.95)	0.94	(0.93–0.95)	0.91	(0.90–0.93)	0.70	(0.68–0.73)

### 3.2. Unadjusted Findings

Table 4 presents the unadjusted relative risk for having 1+, 2+ and 3+ co-occurring chronic conditions for each immigrant category compared to LTOR. Refugees had an elevated relative risk compared to LTOR (1+: 1.25 [95% CI: 1.24 - 1.26]; 2+: 1.36 [95% CI: 1.32 - 1.40]; 3+: 1.19 [95% CI: 1.13 - 1.2]). In contrast, Economic immigrants had a lower relative risk compared to LTOR (1+: 0.90 [95% CI: 0.89 - 0.91]; 2+: 0.87 [95% CI: 0.86 - 0.88]; 3+: 0.67 [95% CI: 0.64 - 0.69]). Family immigrants have no difference in their risk for having 1+ and 2+ co-occurring conditions; however, they had a lower relative risk of 3+ co-occurring conditions compared to LTOR (1+: 1.00 [0.99-1.01]; 2+: 1.00 [0.99-1.02]; 3+: 0.82 [0.79-0.84]). The relative risk of multimorbidity was similar across females and males but higher in the 18-29 age group for refugees and family immigrants. However, the education and income quintile analysis demonstrates that for refugees the disparity was largely driven by those

with a secondary or less education and those in the lowest income quintiles.

### 3.3. Adjusted Multivariate Models

The Hazard Ratios (HR) for having two or more and three or more chronic conditions are shown in Table 5. After adjusting for age, sex, and neighborhood income quintiles, refugees had the highest rate of developing multimorbidity (2+) compared to LTOR (HR:1.25 [95% CI: 1.21 - 1.29]). Family (HR: 0.94 [95% CI: 0.92-0.96]) and Economic immigrants (HR: 0.74 [95% CI: 0.72-0.76]) had a lower risk compared to LTOR. The risk of 3+ multimorbidity remained lower for family and economic immigrants compared to LTOR in the adjusted models. The risk of 2+ and 3+ multimorbidity increased with older age and was lower among women compared to men. The risk also increased with lower neighborhood income quintiles compared to individuals in the higher income quintile groups.

**Table 5. Adjusted hazard ratios and 95% confidence intervals of developing multimorbidity for immigrant categories compared to LTOR.**

Immigrant Categories												
-	Refugee				Family				Economic			
-	N=151, 698				N=417, 422				N=586, 560			
-	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.
<b>Immigrant (Yes)</b>	1.25	(1.21–1.29)	1.05	(0.99–1.11)	0.94	(0.92–0.96)	0.74	(0.72–0.76)	0.84	(0.83–0.85)	0.63	(0.61–0.65)
<b>Age Category</b>	-	-	-	-	-	-	-	-	-	-	-	-
18-29 (reference)	—	—	—	—	—	—	—	—	—	—	—	—
30-44	2.78	(2.67–2.90)	3.6	(3.21–4.00)	2.53	(2.46–2.59)	3.53	(3.29–3.78)	2.68	(2.59–2.78)	3.53	(3.22–3.85)
45+	7.84	(7.49–8.20)	14	(12.4–15.6)	10.9	(10.6–11.2)	24.5	(23.0–26.0)	7	(6.76–7.25)	12.1	(11.0–13.3)

Immigrant Categories												
-	Refugee				Family				Economic			
	N=151, 698				N=417, 422				N=586, 560			
-	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.
<b>Sex</b>	-	-	-	-	-	-	-	-	-	-	-	-
Female	0.87	(0.85–0.89)	0.8	(0.75–0.85)	0.78	(0.76–0.80)	0.66	(0.64–0.68)	0.84	(0.83–0.85)	0.76	(0.74–0.78)
Male (reference)	—	—	—	—	—	—	—	—	—	—	—	—
<b>Income Quintile</b>	-	-	-	-	-	-	-	-	-	-	-	-
Q1 (lowest income)	1.41	(1.34–1.48)	1.57	(1.39–1.76)	1.57	(1.53–1.61)	1.79	(1.70–1.88)	1.56	(1.52–1.60)	1.82	(1.72–1.92)
Q2	1.26	(1.19–1.33)	1.35	(1.20–1.51)	1.38	(1.34–1.41)	1.52	(1.44–1.60)	1.42	(1.38–1.45)	1.55	(1.46–1.65)
Q3	1.19	(1.12–1.26)	1.4	(1.24–1.57)	1.28	(1.25–1.31)	1.34	(1.27–1.41)	1.31	(1.27–1.34)	1.45	(1.37–1.54)
Q4	1.1	(1.04–1.17)	1.1	(0.96–1.25)	1.15	(1.11–1.18)	1.21	(1.15–1.27)	1.19	(1.16–1.23)	1.21	(1.13–1.28)
Q5 (reference)	—	—	—	—	—	—	—	—	—	—	—	—

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

**Table 6. Adjusted hazard ratios and 95% confidence intervals of developing multimorbidity (MM) for immigrant categories compared to LTOR by world region of origin.**

Immigrant Categories													
-	Refugee				-	Family				Economic			
	N=151, 698					N=417, 422				N=586, 560			
-	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.	HR MM (2+)	95% C.I.	HR MM (3+)	95% C.I.	
Caribbean	1.23	1.09–1.38	1.21	0.68–1.73	1.21	1.15–1.27	0.96	0.86–1.06	1.36	1.26–1.46	1.07	0.92–1.22	
East Asia & the Pacific	0.88	0.80–0.98	0.58	0.44–0.73	0.71	0.69–0.73	0.53	0.50–0.56	0.65	0.64–0.66	0.43	0.41–0.45	
Eastern Europe & Central Asia	0.87	0.82–0.92	0.72	0.63–0.81	0.76	0.72–0.80	0.67	0.61–0.73	0.68	0.66–0.70	0.59	0.54–0.64	
Latin America	0.82	0.74–0.91	0.59	0.48–0.71	1.11	1.05–1.17	0.86	0.77–0.95	0.85	0.78–0.92	0.74	0.62–0.86	
North Africa & the Middle East	1.16	1.08–1.24	1.22	1.03–1.42	0.86	0.80–0.92	0.73	0.63–0.83	0.79	0.75–0.83	0.73	0.65–0.82	
South Asia	2.08	1.97–2.18	1.78	1.59–1.98	1.33	1.29–1.37	1.08	1.02–1.14	1.38	1.34–1.42	1.04	0.98–1.12	
Sub-Saharan Africa	1.2	1.12–1.29	0.99	0.83–1.15	0.96	0.88–1.04	0.74	0.62–0.86	0.87	0.80–0.94	0.69	0.55–0.83	
Western Europe & the US	1.71	1.11–2.32	1.63	0.72–2.55	0.71	0.66–0.76	0.69	0.61–0.79	0.54	0.50–0.58	0.46	0.40–0.53	

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

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

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

Table 6 presents the adjusted HRs and 95% CI for each immigrant category by their world region of origin (compared to LTOR) after including the interaction term in the stratified, multivariate models adjusted by age, sex, and neighborhood-level income. Immigrants from the Caribbean and South Asia had the highest risk of multimorbidity across all immigrant categories when compared to LTOR. Refugees from North Africa and the Middle East (HR: 1.16 [95% CI: 1.08 - 1.24]), sub-Saharan Africa (HR: 1.20 [95% CI: 1.12 - 1.29], Western Europe and the USA (HR: 1.71 [95% CI: 1.11 - 2.32]) had a higher risk of 2+ multimorbidity compared to LTOR.

The risk of developing 3+ co-occurring conditions by world region of origin was different by their immigrant

category. Among economic class immigrants, we found no difference by world regions of origin compared to LTOR. Family immigrants from South Asia (HR: 1.08 [95% CI: 1.02-1.14]) had a slightly elevated risk compared to LTOR. Among refugees, the risk was higher among those from North Africa and the Middle East (HR: 1.22 [95% CI: 1.03-1.42]) and South Asia (HR: 1.78 [95% CI: 1.59 - 1.98]) compared to LTOR.

#### 4. DISCUSSION

##### 4.1. Main Findings

Our study showed an association between an immigrant's visa category, their world region of origin and multimorbidity risk in Ontario. Hypertension and diabetes,

and in combination with COPD were the leading multimorbidity dyad and triad groups for all immigrant categories and LTOR.

Refugees had a higher risk of developing 2+ multimorbidity compared to LTOR. Our findings highlight important health disparities within immigrant populations and the complex inter-relationship between migration history, world region of origin and multimorbidity outcomes that are important for policy planning and focusing efforts to address multimorbidity in this heterogeneous population.

For example, immigrants from the Caribbean and South Asia had the highest risk of multimorbidity, irrespective of their immigrant category. Immigrants from certain world regions of origin had a higher risk of multimorbidity that was apparent only within certain immigrant categories. For example, refugees from sub-Saharan Africa had a higher risk, whereas family and economic class immigrants from the same world region had a lower risk compared to LTOR.

When we examined the risk of developing 3+ chronic conditions, refugee and family immigrants from South Asia and refugees from North Africa and the Middle East had a higher risk compared to LTOR, surpassing the risk of immigrants from other world regions of origin.

To date, there has been limited population-based research on multimorbidity incidence among immigrants and its associated risk across different immigrant populations. In Europe, a few emerging studies have investigated multimorbidity among immigrants using both population-based registry and self-reported, cross-sectional data [2, 30, 57-59].

In Norway, Diaz, Kumar and colleagues [57] used data from the National Population Register to estimate the prevalence of multimorbidity among refugees, labour immigrants, family reunification immigrants and education immigrants. They reported a higher risk among refugees and a lower risk among labour and education immigrants when compared to family reunification immigrants. Rates of multimorbidity doubled after a five-year stay in Norway for all immigrant groups [57].

In Denmark, a historical prospective study used data from the Danish National Patient Registry and the Danish Immigration Service to investigate multimorbidity and mortality among refugees and family reunification immigrants from non-Western countries compared to Danish-born citizens [30]. They found that refugees had a higher risk of multimorbidity and family reunification immigrants had a lower risk compared to Danish-born residents [30].

Diaz, Poblador-Pou and colleagues conducted a nationwide multi register study in Norway using data from the National Population Register to examine the associations between multimorbidity and an immigrants' world region of origin compared to individuals born in Norway. Rates of multimorbidity were lower for immigrants from Eastern Europe, Asia, Africa and Latin America, Western Europe and North America compared to

Norwegian-born citizens [2]. In this study, they grouped immigrants from Asia, Africa, and Latin America together in one category, and did not examine immigrants by their immigration classification. However, they reported lower multimorbidity risk among immigrants from Eastern Europe, Western Europe, and North America, findings that are similar to those in our study.

In Spain, Gimeno-Feliu and colleagues [58] conducted a cross-sectional retrospective study of all adults eligible for public health service in Aragon, Spain, to examine the associations with region of origin and length of residence in the host country among immigrants compared to individuals born in Spain. The risk of multimorbidity was lower among immigrants compared to native-born Spaniards but increased with longer duration in Spain. Rates of multimorbidity varied considerably depending on an immigrants' region of origin but continued to remain lower when compared to individuals born in Spain [58].

A cross-sectional study on administrative data in Emilia-Romagna, Italy, estimated the prevalence of multimorbidity by age, gender and citizenship and reported that multimorbidity was significantly more frequent among Italian citizens than among immigrants [59]. These studies did not distinguish between immigrants' visa categories, had a much smaller sample size, and conducted cross-sectional data analysis with the inability to establish causal associations between being an immigrant and the risk of multimorbidity.

#### **4.2. Strengths and Limitations of the Study**

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

We overcame previous methodological limitations by estimating the incidence of multimorbidity among a healthy cohort of immigrants in Canada. Previous research in Canada has largely focused on calculating the prevalence of multimorbidity, with limited ability to distinguish whether the co-occurring conditions existed prior to immigrating to Canada [6].

Our study contained over twenty years of data to examine multimorbidity using nine chronic health conditions from ICES derived disease cohorts defined from previously validated population-derived cohorts using linked data algorithms.

In our study, we defined multimorbidity as two or more and three or more co-occurring chronic conditions. Methods for defining and measuring multimorbidity are evolving and no universal definition currently exists [9, 60]. Our use of administrative health data relied on the quality of the data recorded which is a common limitation for studies that use routinely collected health information [2, 61].

Our analyses did not include lifestyle and behavioural factors, barriers to care and health seeking behaviours. Our data contained migrant characteristics at the time of an



immigrants' landing and included neighborhood-level income only 3 years following their landing. Our data may have also underestimated the immigrant populations' risk of developing multimorbidity, since most chronic condition algorithms used in the ICES-derived disease cohorts favor specificity over sensitivity. Additionally, our study did not include mental health conditions since ICES-derived disease cohorts were not available for mental health conditions at the time of the study.

This limitation is important since several studies have reported that immigrants, particularly refugees, have a greater risk of experiencing adverse mental health outcomes both pre- and post-settlement in a host country [29, 33, 62, 63]. Other studies have also reported an association between mental health conditions and multimorbidity [61, 64, 65]. Prior *et al.* [65] investigated the association between perceived stress and mortality among individuals with multimorbidity using population-based data from the Danish National Health Survey and found an increasing dose-response pattern in mortality rates and stress-associated death among people with multimorbidity.

To our knowledge, two other studies in Europe have examined multimorbidity patterns using mental health conditions among immigrants, compared to native-born individuals, and identified psychiatric disorders and mental health conditions among the most common conditions to co-occur with cardiovascular, respiratory and endocrinological conditions [2, 59]. These findings highlight the complexity of emerging patterns of multimorbidity for immigrants and non-immigrants when including a wide array of both mental and physical health conditions.

### 4.3. Study Implications and Future Directions for Policy and Program Planning

The incidence of multimorbidity is increasing in Canada due in part to an increased rate of individual chronic conditions such as diabetes and hypertension [66]. Findings from our previous research have shown these conditions to be more prevalent among immigrant populations [51]. This current study further revealed emerging patterns of multimorbidity dyads and triads among different immigrant populations and LTOR. Our analyses demonstrate how diabetes and hypertension were the main drivers of the most prevalent multimorbidity dyad and triad groups, suggesting that efforts should aim toward the prevention of these conditions to mitigate the risk of multimorbidity among immigrants.

Current medical guidelines in Canada are geared towards the care and management of patients with individual diseases. This imposes a challenge for primary healthcare professionals who seek to implement evidence-based guidelines when providing care for patients with multimorbidity [67]. This is particularly important for immigrant sub-populations, such as refugees, who often present with a complex medical profile resulting from traumatic events that lead to their migration and post-settlement factors such as access to care and language barriers in navigating the health system.

Findings from this study highlight the need to better understand both the clinical and healthcare system

impacts of multimorbidity to inform the development of guidelines and standards of care, including improvements of existing healthcare programs and services for patients with multimorbidity [67].

This study further highlights the importance of examining the intersecting factors that impact and differentiate the health of immigrant populations. We classified immigrants by their immigration visa category and world region of origin to investigate pre-migratory factors and identify sub-populations at greater risk of multimorbidity.

The primary healthcare system plays a critical role in the management of chronic conditions, including health promotion and disease prevention across various population groups [67]. The rising number of multiple chronic conditions will have significant financial and system-wide impacts relevant to primary healthcare policy and practice [67]. It is important to develop preventative measures as well as design health promotion initiatives that are culturally sensitive and tailored to different populations [67-69].

Our findings can inform future strategies for providing more efficient, coordinated, and cost-effective care that would improve quality of life and reduce hospitalizations [1, 7, 67]. Future studies should examine the impact of common treatments and program initiatives on multimorbidity outcomes across different immigrant populations in order to identify best practices and opportunities for further research and development [68, 69].

## CONCLUSION

Addressing multimorbidity will also require efforts across all levels of government that include improving programs and policies that extend beyond the healthcare system, such as social services as well as settlement and integration policies tailored for immigrant sub-populations at greater risk. This will enable policy and program planners to tackle and address health inequities that stem from the structural and intermediary determinants that impact health and well-being across the immigrant population. As such, routine population-based data collection on immigration status and ethnicity/region of origin is critical to help inform research, policy development, interventions and decision-making that impact long-term investments in preventive health services and management of multimorbidity.

## AUTHORS' CONTRIBUTION

It is hereby acknowledged that all authors have accepted responsibility for the manuscript's content and consented to its submission. They have meticulously reviewed all results and unanimously approved the final version of the manuscript.

## LIST OF ABBREVIATIONS

- IRCC = Immigration, Refugees and Citizenship Canada
- RPDB = The Registered Persons Database

LTOR = Long-term Ontario Residents

MOH = Ministry of Health

MLTC = Ministry of Long-term Care

OHIP = Ontario Health Insurance Plan

## **ETHICS APPROVAL AND CONSENT TO PARTICIPATE**

Ethics approval was obtained from the University of Ottawa Health Science and Science Research and Ethics Board, Canada (Ethics Certificate Number: H02-17-20).

## **HUMAN AND ANIMAL RIGHTS**

All procedures performed in studies involving human participants were in accordance with the ethical standards of institutional and/or research committee and with the 1975 Declaration of Helsinki, as revised in 2013.

## **CONSENT FOR PUBLICATION**

Informed consent was obtained for this study.

## **AVAILABILITY OF DATA AND MATERIALS**

The dataset from this study is held securely in coded form at ICES. While legal data sharing agreements between ICES and data providers (e.g., healthcare organizations and government) prohibit ICES from making the dataset publicly available, access may be granted to those who meet pre-specified criteria for confidential access, available at [www.ices.on.ca/DAS](http://www.ices.on.ca/DAS) (email: [das@ices.on.ca](mailto:das@ices.on.ca)). The full dataset creation plan and underlying analytic code are available from the authors upon request, understanding that the computer programs may rely upon coding templates or macros that are unique to ICES and are therefore either inaccessible or may require modification.

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## **CONFLICT OF INTEREST**

The authors declare no conflict of interest, financial or otherwise.

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not reflect those of the funding or data sources; no endorsement is intended or should be inferred.

## **DISCLOSURE**

Part of this has previously been published in the thesis: Chronic Disease Development and Multimorbidity Among Immigrants and Refugees in Ontario (2021) <http://dx.doi.org/10.20381/ruor-26610>.

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