# Immigration and health disparities: insights from the Canadian Longitudinal Study on Aging

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*For social justice.*

## Abstract

**Background:** The co-occurrence of type 2 diabetes and depression is increasing in Canada and worldwide. Immigrants are particularly vulnerable to these conditions because of the socio-economic, linguistic, and acculturation stressors they experience when moving to a host country. While these inequities in social conditions affect mental health outcomes and diabetes, lack of seeking care may lead to morbidity and mortality. To date, studies have not evaluated the psycho-social consequences tied to being an immigrant over time in terms of the occurrence of depressive symptoms, the compounded relationship between diabetes and depression, and immigrants' involvement in population-based research studies. The overall goal of my thesis was to examine the health disparities in Canadian immigrants compared to non-immigrants in terms of depression risk, the impact of depression on diabetes risk and vice versa, and the completeness of population-based longitudinal data with respect to immigrant information.

**Methods:** I used the Canadian longitudinal study on aging (CLSA), a national prospective cohort that collects psychological, medical, biological, social, lifestyle, and economic data on 51,338 participants recruited between 2012-2015 (ages 45 to 85 years). My thesis includes three manuscripts. In the first manuscript, I used the CLSA Comprehensive cohort (in-person data collection, 30,097 participants) baseline and 18-month follow-up data to evaluate the risks of undiagnosed depression, persistent depressive symptoms, and not seeking mental health care for depressive symptoms in immigrants versus (vs) non-immigrants. In the second manuscript, I used the Comprehensive cohort baseline and 3-year follow-up data (2015-2018) to study the association between depression and diabetes amongst immigrants and non-immigrants. In the third manuscript, I used the combined CLSA Tracking cohort (telephone data collection, 21,241 participants) and Comprehensive cohort baseline and 3-year follow-up data to assess the impact of immigrant status, depression, and language (English, French or Bilingual) on loss to follow-up.

**Results:** My first manuscript showed that female immigrants had higher odds of undiagnosed depression compared to female non-immigrants (odds ratio, OR 1.50, 95% confidence interval, CI 1.25-1.80). However, no difference was observed for males. The odds of persistent depressive symptoms and consulting a mental health care professional for these symptoms at 18 months did not differ between immigrants and non-immigrants. Immigrants with time of residence in Canada

less than 20 years or more than 40 years had higher odds of undiagnosed depression than non-immigrants (OR, 95% CI: 0-5 years 3.30, 1.59-6.85; 6-10 years 1.84, 1.08-3.11; 11-20 years 1.53, 1.02-2.29; 21-40 years 1.03, 0.80 - 1.33; > 40 years 1.21, 1.02-1.43). Immigrants who arrived in Canada at age > 40 years had double the odds of undiagnosed depression compared to non-immigrants (OR, 95% CI: 2.02, 1.43-2.86). My second manuscript demonstrated a higher odds of depression with diabetes among non-immigrants (OR 95% CI: 1.27, 1.08-1.49), but not among immigrants (OR 95% CI: 1.12, 0.80-1.56); depression was associated with increased odds of diabetes in both non-immigrants (OR, 95% CI: 1.39, 1.16-1.68) and immigrants (OR, 95% CI: 1.60, 1.08-2.37). My third manuscript revealed that time of residence ≤ 20 years (OR, 95% CI: 1.84, 1.34-2.35) or arrival at age > 22 years (OR, 95% CI: 1.32, 1.10-1.58) among immigrants, and depression at baseline (OR, 95% CI: 1.23, 1.13-1.46) were associated with higher odds of loss to follow-up from the CLSA. Language was associated with loss to follow-up with no effect modification by depression or immigrant status. Specifically, Bilingual (able to converse in English and French) had lower odds of loss to follow-up than French (able to converse in French, but not English), outside (OR, 95% CI: 0.45, 0.24-0.86) and inside Quebec (OR, 0.78, 95% CI: 0.63-0.98). Loss to follow-up odds was higher in French (vs English, able to converse in English, but not French) outside Quebec (OR, 95% CI: 2.33, 1.19-4.55), but not inside Quebec (OR, 95% CI: 1.18, 0.67-2.08).

**Conclusion:** My studies showed disparities between immigrant and non-immigrant Canadians in the risk of undiagnosed depression, the association between depression and diabetes, and the risk of loss to follow-up at three years. Specifically, the risk of undiagnosed depression was higher among immigrants, particularly female immigrants, those who arrived in Canada at an older age, and those who had resided in Canada for 20 years or less, or more than 40 years. Furthermore, an association between depression at baseline and diabetes 3-year incidence was found in immigrants and in non-immigrants, whereas an association between diabetes at baseline and depression at three years was found only in non-immigrants. My studies have also shown that longitudinal research addressing health disparities between immigrants and non-immigrants may be challenged by loss to follow-up and data completeness. Depression at baseline, immigrant status and language were important determinants of loss to follow-up in the CLSA. Among immigrants, time of residence ≤ 20 years or arrival at age > 22 years increased the risk of loss to follow-up.

## Abrégé

**Contexte:** La cooccurrence du diabète de type 2 et de la dépression augmente au Canada et dans le monde. Les immigrants sont particulièrement vulnérables à ces conditions en raison des facteurs de stress socio-économiques, linguistiques et d'acculturation qu'ils subissent lorsqu'ils déménagent dans un pays d'accueil. Bien que ces inégalités dans les conditions sociales affectent la santé mentale et le diabète chez les individus, le manque de consultations d'un professionnel de la santé et les délais d'utilisation de soins en santé augmentent les risques de morbidité et de mortalité. À ce jour, les études n'ont pas évalué les conséquences psychosociales liées au fait d'être un immigrant au fil du temps en termes de survenue de symptômes dépressifs, de relation aggravée entre le diabète et la dépression et de participation des immigrants à des études de recherche basées sur la population. L'objectif général de ma thèse était d'examiner les disparités en santé chez les immigrants canadiens par rapport aux non-immigrants en termes de risque de dépression non-diagnostiquée, de l'impact de la dépression sur le diabète et vice versa, et de la complétude des enquêtes longitudinales populationnelles en ce qui concerne les informations sur les immigrants.

**Méthodes:** J'ai utilisé les données de l'étude longitudinale canadienne sur le vieillissement (ELCV). ELCV est une étude de cohorte prospective nationale qui recueille des données psychologiques, médicales, biologiques, sociales, de style de vie et économiques sur 51 338 participants recrutés entre 2012 et 2015 et âgés de 45 à 85 ans. Dans mon premier manuscrit, j'ai utilisé les données de base de la cohorte ELCV Compréhensive (collecte de données en personne, 30 097 participants) et les données de suivi à 18 mois pour évaluer les risques de dépression non diagnostiquée, de symptômes dépressifs persistants et de non-consultation de professionnels de la santé mentale pour les personnes affectées par la dépression parmi les immigrants versus (vs) les non-immigrants. Dans mon deuxième manuscrit, j'ai utilisé les données de base et les données de suivi à 3 ans (2015-2018) de la cohorte Compréhensive pour étudier l'association entre la dépression et le diabète chez les immigrants et les non-immigrants. Enfin, dans le troisième manuscrit, j'ai utilisé les données de base et de suivi à trois ans des deux cohortes, ELCV Tracking (collecte de données téléphoniques, 21 241 participants) et Compréhensive, combinées pour évaluer l'impact du statut d'immigrant, de la dépression et de la langue (anglais, français ou bilingue) sur la perte au suivi à trois ans.

**Résultats:** Mon premier manuscrit a montré que les immigrantes avaient un risque plus élevé de dépression non diagnostiquée que les non-immigrantes (rapport de cotes ajusté, OR 1,50; intervalle de confiance à 95%, IC 1,25-1,80), mais aucune différence n'a été observée chez les hommes. Les risques de symptômes dépressifs persistants et la probabilité de ne pas consulter un professionnel de la santé mentale pour ces symptômes à 18 mois ne différaient pas entre les immigrants et les non-immigrants. Les immigrants qui vivaient au Canada depuis moins de 20 ans ou plus de 40 ans avaient un risque plus élevé de dépression non diagnostiquée que les non-immigrants (durée de résidence OR; IC à 95% : 0-5 ans 3,30; 1,59-6,85; 6-10 ans 1,84; 1,08-3,11; 11-20 ans 1,53; 1,02-2,29; 21-40 ans 1.03; 0,80-1,33; > 40 ans 1,21; 1,02-1,43). Les immigrants qui sont arrivés au Canada à l'âge de > 40 ans avaient deux fois plus de risque de souffrir de dépression non diagnostiquée que les non-immigrants (OR IC à 95%: 2,02; 1,43-2,86). Dans mon deuxième manuscrit, j'ai trouvé un risque plus élevé de dépression associé au diabète chez les non-immigrants (OR IC à 95 % : 1,27; 1,08-1,49), mais pas chez les immigrants (OR IC à 95% : 1,12; 0,80-1,56); la dépression était associée à un risque accru de diabète chez les non-immigrants (OR, IC à 95 % : 1,39; 1,16-1,68) et les immigrants (OR, IC à 95 % : 1,60; 1,08-2,37). Mon troisième manuscrit a révélé qu'une durée de résidence des immigrants ≤ 20 ans (OR, IC à 95 % : 1,84; 1,34-2,35) ou leur arrivée à un âge > 22 ans (OR, IC à 95 % : 1,32; 1,10-1,58) et la dépression (OR, 95 % % IC : 1,23; 1,13-1,46) étaient associées à des risques plus élevés de perte au suivi dans le cadre de l'ELCV. La variable langue était associée à la perte au suivi sans modification de l'effet par la dépression ou le statut d'immigrant. Plus précisément, les bilingues (ceux capables de converser en anglais et en français) présentaient un risque de perte au suivi inférieur à celui des francophones (capables de converser en français mais pas en anglais), à l'extérieur (OR, IC à 95 % : 0,45; 0,24-0,86) et à l'intérieur du Québec (0,78; 0,63-0,98). Le risque de perte au suivi était plus élevé chez les francophones (vs les anglophones, capables de converser en anglais mais pas en français) à l'extérieur du Québec (OR, IC à 95 %: 2,33; 1,19-4,55), mais pas à l'intérieur du Québec (OR, 95% CI: 1.18, 0.67-2.08).

**Conclusion:** Mes études ont révélé des disparités entre les Canadiens immigrants et non immigrants quant aux risques de dépression non diagnostiquée, de l'association entre la dépression et le diabète et du risque de perte au suivi au bout de trois ans. Plus précisément, le risque de dépression non diagnostiquée était plus élevé chez les immigrants (en particulier chez les femmes

immigrantes), ceux qui sont arrivés au Canada à un âge plus avancé et ceux qui ont résidé au Canada pendant moins de 20 ans ou plus de 40 ans. De plus, une association entre la dépression et l'incidence du diabète a été trouvée chez les immigrants, mais une relation bidirectionnelle entre la dépression et le diabète a été trouvée chez les non-immigrants. Mes études ont également démontré que la perte au suivi et la complétude des données constituent des défis à la recherche longitudinale portant sur les disparités en santé des immigrants. La dépression, le statut d'immigrant et la langue étaient associées à des risques plus élevés de perte au suivi dans le cadre de l'ELCV. Parmi les immigrants, une durée de résidence ≤ 20 ans et leur arrivée à un âge > 22 ans augmentaient le risque de la perte au suivi.

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## Contribution to original knowledge

I hereby certify that I am the sole author of this thesis and I certify that, to the best of my knowledge, my thesis does not infringe upon anyone's copyright nor violate any proprietary rights and that any ideas, techniques, quotations, or any other material from the work of other people included in my thesis, published or otherwise, are fully acknowledged in accordance with the standard referencing practices. Furthermore, to the extent that I have included copyrighted material that surpasses the bounds of fair dealing within the meaning of the Canada Copyright Act, I certify that I have obtained a written permission from the copyright owner(s) to include such material(s) in my thesis and have included copies of such copyright clearances to my appendix.

I declare that this is a true copy of my thesis, including any final revisions, as approved by my thesis committee and the Graduate Studies office, and that this thesis has not been submitted for a higher degree to any other University or Institution.

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## Contribution of Authors

**Manuscript 1**: "*Undiagnosed depression, persistent depressive symptoms and seeking mental health care: analysis of immigrant and non-immigrant participants of the Canadian Longitudinal Study of Aging*", Published August 14th 2020 in Epidemiology and Psychiatric Sciences (Impact factor 6.9, 2020).

**Manuscript 2:** "*Depression, diabetes and immigration status: a retrospective cohort study using the Canadian Longitudinal Study on Aging*", Published June 14th, 2022 in Canadian Medical Association Journal Open (Impact factor 8.3, 2020).

For Manuscripts 1 and 2, I conceived the idea, performed the analyses, interpreted the results and drafted the manuscript. Elham Rahme conceived the idea, acquired the data, supervised the analyses, interpreted the findings and edited the manuscript. Kaberi Dasgupta, Patricia Li, Jason abo and Waqqas Afif provided content expertise and thoughtful comments throughout the process and edited the manuscript. All authors read and approved the final draft of the manuscripts.

**Manuscript 3:** "*Determinants of loss to follow-up in the Canadian longitudinal study on aging: a retrospective cohort study*" Published September 22nd, 2022 in BMJ, Journal of Epidemiology and Community Health (Impact factor 6.3, 2019).

For Manuscript 3, I conceived the idea, performed the analyses, interpreted the results and drafted the manuscript. Elham Rahme conceived the idea, acquired the data, supervised the analyses, interpreted the findings and edited the manuscript. Kaberi Dasgupta and Patricia Li provided content expertise and thoughtful comments throughout the process and edited the manuscript. All authors read and approved the final draft of the manuscripts.

## List of Abbreviations

BIC= Bayesian information criterion

CCHS= Canadian Community Health Survey

CES-D-10= Center for Epidemiological Studies Depression

CHMS= Canadian Health Measures Survey

CI= Confidence interval

CIDI= Composite International Diagnostic Interview

CIHR= Canadian Institutes of Health Research

CLSA= Canadian Longitudinal Study on Aging

CPES= Collaborative Psychiatric Epidemiology Surveys

DS= Depressive symptoms

ELCV= Étude longitudinale canadienne sur le vieillissement

FU= Follow-up

HIE= Healthy Immigrant Effect

Hispanic EPESE= Hispanic Established Population for the Epidemiological Study of the Elderly

K10= Kessler Psychological Distress Scale 10

LFU= Loss to follow-up

LSIC= Longitudinal Survey of Immigrants to Canada

MESA= Multi-Ethnic Study of Atherosclerosis

MHC= Mental health care

MHCP= Mental health care professional

NHIS= National Health Interview Surveys

NLAAS= National Latino and Asian American Study

NPHS= National Population Health Survey

OR= Odds ratio

PINE= Population Study of Chinese Elderly

SD= Standard Deviation

UD= Undiagnosed Depression

U.S.= United States

WHO= World Health Organization

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## Overview

The overall goal of my thesis was to examine the health disparities in community dwelling middle-aged to older Canadian immigrants compared to non-immigrants in terms of depression and diabetes risks and the limitations of the longitudinal data used to study changes in immigrants' health over time.

This thesis is manuscript based. Chapter I presents the introduction to the main reasons that motivated this work. Chapter II provides a literature review. Chapter III provides an overview of the data source used in this thesis. Chapters IV-VI include the three manuscripts addressing the three objectives of this thesis. Chapter VII summarizes the findings from the three manuscripts, provides a discussion of the overall strengths and limitations of the studies, suggests future directions, and provides a conclusion from the current work.

# Chapter I: Introduction

## Immigrants in Canada

Canada ranked one of the top among G8 countries in proportion of foreign-born nationals in the latest 2016 National Population Household Survey (NPHS) (1). Immigration is an important component of population growth in the country where immigrants made up 22% of the population in 2016, and are expected to reach at least 25% of the population by 2031 (2). In the last five years, the largest regions of origin of Canadian immigrants were Asia, the Middle East, Africa, the Caribbean, and Central and South America (3). Approximately 6 out of 10 immigrants were economic immigrants, and settled mostly in large Canadian cities (4). *The immigration of populations of this size has important implications for immigrants and health systems.*

Immigrating is a stressful life event that involves uprooting from one's home, relocating, and adapting to a host country (5, 6). Many immigrants face macro- and micro- level challenges to integration, which can be problematic for their physical and mental health wellbeing (7-9). From a macro-level perspective, structural and organizational pressures may affect immigrants with poor socioeconomic integration, systemic alienation, and fewer employment opportunities (7, 8, 10, 11). Additionally, immigrants undergo a re-learning curve in order to access and navigate new systems (12-14). For example, immigrants need to learn how to access a family doctor or how to land a job interview by identifying system differences. In the process, they may face discrimination and racism because of their differences in language, skin colour, and culture (15-19). From a micro-level perspective, immigrants tackle an unknown future while experiencing acculturative stress and adapting to a new culture (20, 21). Adapting to a new culture comes with individualized changes in diet and lifestyle (22), learn new behaviors for proper adaptation and unlearn some aspects of their culture of origin, and a need to develop new social support and networks (23, 24). *Acculturative stress may impact immigrants' physical and mental health as well as their access to health services which may delay diagnosis and treatment of chronic disorders and increase their risk of complications (25-28).*

## Mental health disparities

To date, the studies that examined mental health disparities between immigrants and non-immigrants with respect to depression had mixed results with most showing lower risks in immigrants (29-38), while others reporting higher risks (8, 15, 39). Those studies that examined factors associated with the risk of depression in immigrants have identified, female sex, single status, younger age, pain, alcohol dependence and functional limitations as predictors (31, 40), with factors such as time of residence, age at immigration, education attainment, and employment status also affecting this risk (15, 41-44). However, with the exception of four retrospective cohort studies (8, 29, 38, 45), the aforementioned studies were cross-sectional, which limits the ability to infer a reliable causal association between immigrant status and mental illness based on their findings (15, 46-48). Among the four retrospective cohort studies (8, 29, 38, 45), two were conducted in Europe (29, 45), one in Canada (38) and one in the United States (U.S.) (8). In two of these studies, immigrants had higher risks of depression compared to non-immigrants (8, 45). However, one of these studies was conducted in the U.S. over 20 years ago (8) and the other was conducted in Sweden (45). In contrast, the remaining two cohorts suggested that immigrants had better mental health outcomes than non-immigrants (29, 38). One of these studies was conducted in the U.S. and the other was conducted in Canada. However, the Canadian study was restricted to younger immigrants (ages 15 to 65 years) and was limited by a small sample size and a high attrition rate (38). *Given the differences in immigration policies, ethnic and socio-economic composition of immigrants and migration trends over time, studies conducted outside Canada have limited generalizability to the Canadian context. Additional studies are needed to evaluate the mental health outcomes in immigrants and non-immigrants in Canada.*

## Seeking and receiving care

While disparities in depression risk between immigrants and non-immigrants is itself an important area of study, it is equally important to ascertain disparities in seeking and receiving mental health care between immigrants and non-immigrants (33, 38, 49-54). Studies conducted in Canada (38, 50, 54), U.S. (53), and Norway (52) showed that the rates of mental health care service utilization were generally lower in immigrants than in native-born citizens despite an equal or greater need

in immigrants. The difference in rates was not explained by differences in somatic or psychological symptoms, time of residence or use of alternative sources of help (54). However, some sex variations were found with immigrant males reporting to be less likely to perceive needing mental health care than immigrant females (51, 53). Additionally, these studies reported differences in seeking mental health care by immigrant's country of origin (38, 52, 53). Reasons for not seeking mental health care among immigrants included fear of stigma and discrimination (24, 55, 56) and cultural and linguistic barriers of care (54, 57, 58). From a health systems perspective, immigrants were found not to receive care when they did not report mood-related symptoms to healthcare professionals fearing stigma or discrimination or when there was lack of mental health care resources (59-61).

Differences in attempts to seeking mental health care between immigrants and non-immigrants are poorly understood. Lack of recognition of depressive symptoms and reluctance to seek mental health care for these symptoms delay diagnosis and increase the risk of complications (62, 63). To date, the prevalence of undiagnosed depression and not seeking mental health care is still undetermined in immigrants compared to non-immigrants in Canada (15, 46). *Given the prominence of immigrants in Canada (64, 65) and the fact that mental health disorders have become a rising burden to society (66), it is important to examine the mental health status of Canada's immigrants. Disease prevention is preferable to disease treatment considering the high social and economic costs of depressive disorders. In Canada, treating depression costed over $12 billion in direct health care expenditures in 2016 (67), and another $8 billion in indirect expenditures related to lost productivity (68).*

## Depression and type 2 diabetes

While there are many contextual and structural reasons why immigrants may be at higher risk for depressed mood and limited access to care compared to non-immigrants, chronic physical health impairments may also increase the risk for depressed mood. In general, immigrants tend to be healthier than native-born populations in the first few years following their arrival (69, 70), although this 'Healthy Immigrant Effect' appears not to operate in the case of type 2 diabetes. A study using a large administrative database of immigrants to Ontario in 2005 showed that male and female immigrants from the Caribbean, Latin America, South Asia, and sub-Saharan Africa who have resided in Canada for less than 20 years had 2 to 3 times higher risks of type 2 diabetes

compared to male and female immigrants with > 20 years of residence, respectively (71). In contrast, higher risks by increased time of residence were shown by another Canadian study using the 2007-2008 Canadian Community Health Survey (CCHS). In this study, immigrants experienced a 20% higher risk of diabetes compared to Canadian-born individuals and immigrants with > 5 years of residence were 70% more likely to report having diabetes compared to recent (≤ 5 years) immigrants (72). Differences in ethnic background may explain some of these discrepancies in results. Indeed, the study from Ontario showed that immigrants from Western Europe and North America developed diabetes later in life (ages 35 to 49 years) compared to those from other regions (ages 20 to 40 years) (71). In addition, differences in dietary acculturation (fewer vegetables and higher caloric consumption) between ethnic groups have been reported and may have affected the risk of diabetes (73).

Given the heightened socio-economic inequities, vulnerabilities, and acculturative stress experienced by immigrants, studies have reported that immigrants with diabetes might have a synergic risk of having depressive symptoms compared to the general host population (74, 75) and to the population in their country of origin (11, 76-81). Immigrants with depressive symptoms may also be at higher risk for diabetes because of complex social determinants of health (82-85) and delays in depression diagnosis and treatment (23, 83, 86-88). *Co-existence of depressive symptoms and diabetes can increase the health burden and complications in general, and more so in vulnerable populations such as the immigrants (89, 90).*

The association between diabetes and depression has been evaluated in the general population (91-97) and a possible two-way relationship has been proposed (98): meaning that diabetes can cause individuals to become depressed over time and that depression can cause individuals to develop diabetes over time. However, this association has not been specifically studied in immigrants. *While immigrants are one of the leading economic forces of Canada, the health burden from the co-occurrence of diabetes and depression in this group can lead to lack of productivity that may affect the entire population. The current Canadian Collaboration for Immigrant and Refugee Health recommends screening of immigrants for diabetes and depression, particularly those of Latin American, African, and South Asian origin over the age of 35 years (83).*

## Data quality and completeness

While there can be several physiological reasons that may explain the variations of the reported findings of the studies that assessed the risk of depression and diabetes in immigrants and non-immigrants, methodological approaches and study completion are important to ascertain the quality of the data and the accuracy of the results. Causal association cannot be inferred from cross-sectional studies and longitudinal study designs are needed for this purpose. For example, a longitudinal study design is needed to examine whether diabetes increases the risk of depression and whether depression increases the risk of diabetes (99-104). High-quality population-based prospective cohorts such as the Canadian Longitudinal Study on Aging (CLSA) offer the possibility of evaluating health disparities and their trajectories in ageing Canadian immigrants and non-immigrants (105). However, there are issues that may compromise the validity of longitudinal studies, including participation biases and loss to follow-up (99-104). Previous studies have found that participants with mental illnesses were more likely to drop out from a longitudinal cohort study compared to those without these illnesses (101, 106, 107). Older age, non-White ethnicity, male sex, limited education, and poor self-reported health have also been associated with loss to follow-up (101, 108). Non-random loss to follow-up needs to be examined and properly addressed in the analyses to ensure internal and external validity of the research findings (99, 100, 109-111). Immigrants differ from non-immigrants in lifestyle habits, language barriers, and mental health risk factors, which may play a role in their continuation in cohort studies. Therefore, challenges to retention in longitudinal cohort studies may also differ for immigrants compared to non-immigrants (112, 113). *It is important to examine factors that contributed to loss to follow-up in the CLSA in immigrants versus (vs) non-immigrants and study the modifying effect of depression and language to inform appropriate data analyses and avoid biased findings.*

In summary, the available literature points to the need for more research on the relevant risk factors of physical and mental health disparities between immigrants and non-immigrants. The prevalence of undiagnosed depression, persistent depressive symptoms, and seeking mental health care for depressive symptoms is still undetermined in immigrants compared to non-immigrants in Canada. Additionally, the higher rates of diabetes in immigrant populations and the possible association between diabetes and depression requires further attention. Finally, evaluation of loss to follow-up in cohort studies with special attention to differences between immigrants and the general

population remains to be understood. Additional information on these issues may inform public health programs aimed at improving the health and wellbeing of the Canadian population and at reducing health disparity between immigrants and non-immigrants.

Research Questions

My research sought to address these knowledge gaps by answering the following questions:

1. What are the rates of undiagnosed depression in immigrants and non-immigrants?
2. Are there differences in these rates by sex, time of residence, and age at immigration?
3. Do depressive symptoms persist over time and are there differences between immigrants and non-immigrants?
4. Do immigrants and non-immigrants seek mental health care at the same rate?
5. What are the rates of diabetes and depression in immigrants and non-immigrants?
6. What is the impact of depression on the risk of diabetes in immigrants compared to non-immigrants, and is the association between diabetes and depression bidirectional?
7. Are there differences in early loss to follow-up in immigrants and non-immigrants in the CLSA cohort?
8. How does immigrant status, depression, and language impact loss to follow-up in that cohort?

I conducted three studies. In the first study, I assessed the prevalence of undiagnosed depression and its predictors in immigrants and non-immigrants (ages 45 to 85 years). I then investigated whether depressive symptoms persisted after 18 months of follow-up as well as if there was a difference in accessing mental health care between immigrants and Canadian-born individuals. In the second study, I examined the impact of depressive symptoms on the incidence of diabetes and the impact of diabetes status on the incidence of depressive symptoms in immigrants and non-immigrants over a 3-year follow-up period. Finally, in the third study, I explored the determinants of 3-year loss to follow-up in the CLSA and the effect modification of immigrant status, language groups and depressive symptoms.

# Chapter II: Literature Review

## Immigrants to Canada

Immigration policies influence the demographics of our society by impacting age-distribution, ethnic composition, and health trajectories. In Canada, continuous migration has been a primary driver accounting for 75% of population growth (1, 114). These policies intended to counter-act the demographic and economic effects of a declining birth rate of an aging population as well as improve sources of human resources by giving preferences to skilled workers and economic immigrants. Based on the Citizenship Act and the Immigration and Refugee Protection Act as of 1962, selection criteria to Canada do not discriminate based on race, religion or national origin but only deem inadmissible those who have health, legal or other reasons (115). Since 1989, Canada receives between 200,000 and 300,000 new immigrants per year, mainly under the economic category (116, 117). In the most recent Canadian Census conducted in 2016, immigrants represented 22% of the overall Canadian population (65). The largest ethnic groups originated from the Philippines, India and China, and were mostly living in urban contexts (1). Receiving around 45% of all immigrants to Canada, Ontario was the most popular destination then British Columbia and Quebec (118). Immigrants tend to also migrate at a relatively young age. In 2011, approximately 59% of immigrants came to Canada when they were between 25 and 54 years of age (3, 119). Projections show that by 2036, immigrants would represent between 25% and 30% of the Canadian population, with the majority of them being born in Asia, and their mother tongue being neither English or French (120).

## Immigration and acculturation

When arriving to a new country, immigrants need to adapt to macro and micro experiences (91-94). In 1936, researchers introduced the concept of acculturation (121). Acculturation occurs when "a group of individuals having different cultures come into continuous first-hand contact with subsequent changes in the original culture patterns" (121). According to Berry (1989), acculturation is a major life event highlighted by stress that demands cognitive appraisal of the situation, time, and coping strategies (122). There are four acculturation strategies: integration, assimilation, marginalization and separation. The optimal strategy that balances cultures and

psychological domains is integration (123-125). Immigrants relinquish some elements of their culture of origin and learn new behaviors of adaptation, what researchers call "culture shedding. When adapting and coping is not achieved, "culture shock" and acculturative stress occur and could persist leading to psychopathology (126), depression, and comorbidity (127). Adapting and coping levels seem to differ between male and female immigrants, with females being more affected by acculturative stressors (120, 128). Adapting and coping levels also differ by age at immigration, education, and behavioural orientation (56, 129, 130).

## Social determinant of health

Researchers categorize immigration as a social determinant of health in its own right (131). Upon landing in Canada, immigrants are typically healthier than the average Canadian-born individuals (32, 46, 69, 70, 132, 133). Several contributors to the "Healthy Immigrant Effect" involves self-selection (being able to migrate and motivated to do so) and immigrant selection procedures (exclude serious medical conditions) (69, 70, 134). Canadian-born individuals have been surpassed by immigrants in some health measures such as lower mortality rate (135, 136), lower incidence of chronic conditions (asthma (137), obesity (138, 139)), and better self-reported health (133, 140). However, these health advantages seem to decrease with time spent in Canada especially in high-risk subgroups of immigrants such as low-income, seniors and women (15, 22, 44, 46, 69). In general, the noted decline in immigrants' health seem to be influenced by acculturation and stress-coping associated with the cumulative exposure to various stressors at different levels: individual (e.g. financial constraints, language issues), societal (e.g. discrimination, racism, unequal job opportunities) and organizational (e.g. difficulties navigating food, housing, health and social care systems) (141-144). This accumulation of stressors adds up to cause a dysregulation of physiological mediators, resulting in physical and mental health deterioration (141, 145). For example, Allen and colleagues (2014) found that poor and disadvantaged populations such as immigrants were most affected by mental disorders, and that cumulative stress served as a mechanism through which the impact of social determinants multiplies across the lifespan (40). In terms of physical health, Lear and colleagues (2009) found that immigrants presented with an increased burden of sub-clinical atherosclerosis that surpassed that of non-immigrants and increased by time since immigration (146). After adjustment for confounding factors, they found that for every ten years since immigration, there was a 2% increase in intima-media thickness of

the carotid artery in addition to 7% increase for every 10 years of age. *Despite successfully "escaping" from strains and difficulties in the country of origin, immigrants seem to face further challenges post-immigration (147-150).*

## Socio-economic disparity

Census and survey data show that while the education attainment of immigrants in Canada is higher than that of the Canadian-born population, unemployment rate is also higher and income is lower in immigrants (151, 152). This phenomena has been observed in male and female immigrants (153). However, as in the general population, sex disparity exist among immigrants with regard to unemployment and income with immigrant females obtaining lower employment income compared to immigrant males (153). A recent analysis of the Canadian Labour Force Survey (March 2022) reported a 3.8% higher unemployment rate among immigrants compared to the Canadian-born population (151). In addition, data from the 2016 Census showed that 40% of immigrants ages 25 to 64 years had a university degree compared to 25% of their Canadian-born counterparts, while employment rates were lower in immigrants (68.5% in recent immigrants, 79.5% in established immigrants, and 82.0% in the Canadian-born population 25-54 years old) (152). Earlier data showed that immigrants who arrived in Canada in 2004 were three times more likely to have low income compared to the Canadian-born population (2006 Census) (154), and about 30% of immigrant families lived below the officially defined poverty line at that time (155, 156). Low income and poverty can influence an individual's nutrition, housing stability, social participation, and health outcomes (11, 157-160). *Poverty not only increases the likelihood of exposure to risk factors for diseases, mental health decline, and depression (11, 161-164), but is also a barrier to accessing appropriate treatment because of cost (53).*

## Language disparity

Linguistic adaptation of immigrants to a new host culture can be challenging (54, 57, 58, 104, 134). In Canada, there are two official languages: English and French. However, nearly 6.6 million people (one fifth of the Canadian population) speak a language other than French or English at home and 30% of these individuals do not speak either official language at home (1). In medical settings, communication barriers have been recognized to cause medical errors (5, 165-167). Not

speaking the language of the majority may be associated with mental and physical health decline because of the sense of isolation and difficulty accessing the healthcare system (2,4). For example, Montemitro and colleagues (2021) conducted a systematic review of 41 studies and found that inadequate language proficiency was associated with psychotic disorders, mood, anxiety, and post-traumatic stress disorders in immigrants (134). Similarly, using the National Latino and Asian American Study (NLAAS) survey, Takeuchi and colleagues (2007) found that English-language proficiency was associated with lower risk of depressive disorders (lifetime and 12-month) among Asian men living in the U.S. (168); *language is an important determinant of health in immigrants.*

## Social support disparity

A large social network has been associated with higher life satisfaction, as well as better self-reported mental and physical health statuses (169, 170). When moving to Canada, immigrants usually have a smaller network of friends and acquaintances than what they previously had in their home country and than that of the Canadian-born population. Statistics Canada's General Social Survey (2008) compared the size and structure of the networks of both immigrants and Canadian-born individuals (171). Immigrants were found to have fewer social connections in terms of family, friends and acquaintances than the Canadian-born population. An analysis of the 2009-2010 CCHS data by Chadwick and colleagues (2017) revealed that high social support availability was associated with better self-perceived mental health status (172). Similarly, in an analysis of the Project on Human Development in Chicago Neighbourhoods data, Almeida and colleagues (2011) found that support from family and kins had a protective effect on the risk of depression in foreign-born Americans (173). *Social support may attenuate the impact of acculturative stress and vulnerability on mental and physical health of immigrants (174, 175).*

## Mental health disparity

The World Health Organization (WHO) defines mental health as a "state of well-being in which the individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to their own community" (66). Mental wellbeing is associated with coping skills such as resilience, flexibility and balance and is intrinsic to overall good physical health and quality of life (176). Mental wellbeing depends on a

complex interaction between risk factors that jeopardize it and social-psychological factors that protect it (31). Studies have reported a strong association between depression and physical health, productivity, and premature death (177-179). The prevalence of known prognostic factors, such as physical illness, cognitive impairment, and lack of support, increase with age, suggesting that the prognosis may deteriorate in later life (180, 181). Some studies have shown that 30% to 50% of primary care patients with depressive disorders have symptoms that persist over six to twelve months, and that severity of symptoms, age and presence of co-morbidity were predictors of this persistence (182, 183). Nevertheless, long-term outcomes and factors affecting prognosis of depressive disorders remain far from clear (184). Depression was also found to have a substantial economic burden on the society (185, 186). Using the 2009-2013 estimate of the labour force, depression-related mean cost of productivity due to absenteeism from work in Canada was estimated to be $4,270 USD/person/year (179).

Among immigrants, the prevalence of depression is influenced by the immigration experience (adversities before, during and after resettlement) (24) and its inherent stress in adjusting to life in the host country (11, 187). Living alone, lower self-reported language proficiency, low social involvement scores, and low income have been reported to increase the risk of psychological distress in immigrants. In addition, immigration-related factors such as time of residence and age at immigration may also affect this risk (30-39). Stress is known to be a major risk factor for depression (128, 163). Acculturative stress in immigrants has been associated with low self-esteem and low psychological well-being which could possibly lead to depression (130, 188). The Longitudinal Survey of Immigrants to Canada (LSIC) was conducted by Statistics Canada and Citizenship and Immigration Canada between 2001 and 2005 to evaluate immigrants' health (189). A report from this survey showed that 29% of immigrants who arrived in Canada between 2000 and 2004 reported having emotional problems and 16% reported high levels of stress (189). However, as reviewed in the next section, studies examining the risk of depressive symptoms in immigrants compared to non-immigrants had mixed results with most reporting lower risks of depressive symptoms in immigrants compared to non-immigrants (29-38) and others reporting no difference in risks (32) or higher risks (8, 39). *Discrepancy in these results may be attributed to the study design, ethnic mix, time of residence, and self-reporting bias (190).*

The studies that examined the risk of depression in immigrants compared to non-immigrants were mostly cross-sectional with only four retrospective cohort studies examining this issue (8, 29, 38, 45) (Table 1). Two of the studies were conducted in Europe (29, 45), one in Canada (38) and one in the United States (U.S.) (8). In two of these studies, immigrants had higher risks of depression compared to non-immigrants (8, 45). The first of these studies was conducted by Helgesson and colleagues (2019) in Sweden and compared Western and non-Western migrants to natives Swedes from 1991 to 2008 (45). It found that non-Western immigrants demonstrated 36% higher adjusted hazards for psychiatric disorders. The second study was conducted in the U.S. by Wilmoth and colleagues (2003) among immigrants and non-immigrants (ages 51 to 61 years) from 1992 to 1994. It showed that immigrants with depressive symptoms at baseline were more likely to also have depressive symptoms in follow-up (8). In contrast, the remaining two studies suggested that immigrants had better mental health outcomes than non-immigrants (29, 38). One of these studies by Ronda-Pérez and colleagues (2019) was a 1-year follow-up study (2015-2016) conducted in Spain. This study found that recent immigrants had lower incidence of common mental health disorders than Spanish-born individuals and immigrants who had resided in Spain for more than 15 years (29). The study did not assess the risk of depression separately. The fourth study was a 2-year follow-up study conducted by Whitley and colleagues (2017) in Montreal among immigrants and non-immigrants ages 15 to 45 years from 2007-2015. Immigrants in that study had lived 20 years in Canada on average and had lower rates of high psychological distress, depression, and alcohol dependence than non-immigrants (38). Immigrants had also higher scores of mental wellbeing, satisfaction with social life, and personal relationship. Of note, this study had a small sample size and a high attrition rate which may have biased its results if immigrants experiencing psychological distress were more likely to drop out from the study. *Cultural differences in disclosing personal information and mental health expectations may explain, at least in part the discrepancy in these study results (58, 191-193).*

All other studies that examined the risk of depressive symptoms in immigrant and non-immigrants were cross-sectional (30-37, 39) (Table 1). Among these, all of the Canadian studies reported lower risks of mental health disorders in immigrants compared to non-immigrants (31-37). For example, Lou and Beaujot (2005) analyzed the CCHS data and found that the proportion of self-rated poor mental health among the foreign-born population was lower than that of the Canadian-born

population (6.0% and 7.0%, respectively) (32). They also found that male immigrants were significantly less likely to report poor mental health status compared to female immigrants. Using the same database (CCHS, 2000 to 2001), Ali (2002) found that recent immigrants (< 5 years of residence) had lower rates of depression and of alcohol dependence compared to the Canadian-born population (31). However, the risks of depression among those who had arrived between 10 and 14 years ago or more than 20 years ago were not significantly different from that of the Canadian-born population; the authors did not examine differences between immigrant males and immigrant females. In a third Canadian study, using six cycles of the NPHS from 1994 to 2005 in respondents (ages 15 years and older), Pahwa and colleagues (2012) found an inverted U-shaped relationship between time of residence and mental distress (37). Specifically, compared to those who resided in Canada for more than 20 years, those who resided 2-20 years were significantly more likely to report moderate to high levels of mental distress (OR 1.27, CI:1.09-1.49), while those who resided for less than two years were as likely to report such levels of mental distress. The authors did not examine sex-differences in the relationship between time of residence and mental distress level. However, they found a relationship between ethnicity and mental distress level that was modified by immigrant status and sex. Similarly, Salami (2017) analyzed three cycles of the Canadian Health Measures Survey (CHMS; 2007-2013) and found that recent (< 5 years of residence) immigrants had better self-rated mental health compared to long-term immigrants (33). Rates were similar between Canadian-born individuals and long-term (> 10 years of residence) immigrants.

Cross-sectional studies from other countries examining the risk of depressive symptoms in immigrants and non-immigrants showed mixed results (30, 39, 194) (Table 1). For example, when comparing European countries, Gkiouleka and colleagues (2018) reported higher prevalence of depressive symptoms in immigrants compared to non-immigrants in Switzerland, Germany, Denmark, France, the Netherlands, Norway, Poland, and Sweden, but not for U.K. and Greece (39). In contrast, in a U.S. study, Ikonte and colleagues (2020) found that immigrants were 11% less likely to be depressed compared to US-born individuals (30). In that study, the prevalence of depression increased in immigrants as time of residence increased. In another study in Australia using online survey of a convenience sample of Australians (mean age 35 ± SD 6.0), Demuska and colleagues (2021) found that depression was higher in Anglo-Australians compared to the

Russian-speaking immigrant and the Russian-speaking non-immigrant groups (194). These cross-sectional studies conducted worldwide reported conflicting results in prevalence of depression and depressive symptoms between immigrants and non-immigrants (30, 39, 194). *Differences in immigration policy, ethnic mix, language and socio-economic conditions between countries may influence the mental health of immigrants and may explain some of the differences in results between countries, while study design and methodological differences may explain discrepancies in results from the same country.*

My search of the literature did not find any study that evaluated the prevalence and determinants of undiagnosed depression and related sex differences in immigrants compared to non-immigrants. My search identified only the study by Wilmoth and colleagues (2003) that examined persistent depressive symptoms in immigrants in the U.S. (Table 1). As mentioned above, this study reported a higher risk of persistent depressive symptoms at two years among immigrants compared to non-immigrants. However, this study is three decades old (1992-1994) and has limited generalizability to the current Canadian context.

In summary, the risk of depression in immigrants vs non-immigrants remain poorly understood. Most studies examining this risk were cross-sectional which limits the ability to infer a reliable causal association between immigrant status and mental illness based on their results (30-37, 39). My search yielded only four studies that used a longitudinal design to examine this issue. Three of these studies were conducted in foreign countries with different immigration policies and migratory trends than those in Canada and the fourth study having out-dated results (1992-1994). The only study that was conducted in Canada included younger immigrants and was limited by a small sample size, high attrition rate and only one geographical setting (Montreal) where immigrants live in high-immigrant-density-neighborhoods and may have different depression risk than those who live in other geographical settings (38).

Table 1. Summary of the studies showing depressive symptoms in immigrants compared to non-immigrants

| Author, year of publication (Country) | Data source (Study design) | Study population | Exposure | Outcome | Findings |
|---|---|---|---|---|---|
| | | | *Canadian Studies* | | |
| **Whitley, 2017 (Canada) (38)** | The Epidemiological Catchment Area Study of Montreal South-West study from 2007 to 2015<br><br>(Retrospective cohort study) | Immigrants (on average resided 20 years in Canada) and non-immigrants (ages 15 to 65 years; N= 2,433) | Immigrant status, health services utilization, time of residence and region of origin | Mental health status | Immigrants (vs non-immigrants) had lower rates of high psychological distress (32.6% vs 39.1%), alcohol dependence (1.4% vs 3.9%), depression (5.2% vs 9.2%). Immigrants had higher scores of mental well-being, satisfaction with social and personal relationships. Asian and African immigrants had particularly low rates of health services utilization. |
| **Pahwa, 2012 (Canada) (37)** | Six cycles of the National Population Health Survey (NPHS) from 1994 to 2005<br><br>(Cross-sectional study) | Canadians (ages 15 years and older; N= 14,713 respondents) | Ethnicity, immigrant status and time of residence | Mental distress (K10) | The relationship between ethnicity and mental distress was modified by immigrant status, sex, social involvement score and education. An inverted U-shaped relationship between time of residence and mental distress was found: those who had lived in Canada for less than 2 years were less likely to report moderate/high mental distress, while those who had lived in Canada for 2 to 20 years were more likely to report moderate/high mental distress than those who had lived in Canada for more than 20 years. |
| **Menezes, 2011 (Canada) (36)** | The Canadian Community Health Survey (CCHS), Cycle 1.2 in 2002 and Canadian Census of Population in 2001<br><br>(Cross-sectional study) | Canadians (ages 16 years and older; N= 35,708) | Immigrant status and neighborhood concentration | 12-month psychiatric disorder | Immigrants had lower prevalence of psychiatric disorder than non-immigrants, with an added protective effect for immigrants living in neighborhoods with higher immigrant concentrations. Immigrant concentration was not associated with elevated prevalence of psychiatric disorder among non-immigrants. |
| **Stafford, 2010 (Canada) (35)** | The CCHS, Cycle 1.1 from 2000 to 2001 and the Canadian Census of Population in 2001<br><br>(Cross-sectional study) | Canadians (ages 12 years and older; N= 112,939) | Immigrant status and density of immigrants per region | Depression (CIDI and DSM-IV) | Immigrant and visible minority residents were less likely depressed vs the general population. Increasing percentage of immigrants in the region was marginally associated with a higher likelihood of depression among Whites, and a lower likelihood of depression among visible minorities. |
| **Wu, 2005 (Canada) (34)** | The NPHS Cycle 2 from 1996 to 1997 | 10,972 females and 59,566 males | Immigrant status and time of residence (< 5, 5-9, | Depressive symptoms and major | Immigrants (residing <19 years, 30-34 years, and 40 years or more) had fewer depressive symptoms vs non-immigrants. |

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| | (Cross-sectional study) | | 30-34, and > 40 years) | depressive episode (DSM-III-R) | All other immigrants had similar levels of depression as non-immigrants. |
| **Salami, 2017 (Canada) (33)** | Three cycles of the Canadian Health Measures Survey (CHMS) from 2007 to 2013 and qualitative interviews and focus groups of service providers<br><br>(Cross-sectional study and interviews; mixed-methods study) | Canadians (ages 15 to 79 years; N= 12,160) and 53 immigrant service provider in Alberta | Immigrant status and time of residence | Self-perceived mental health status | Recent immigrants (< 5 years of residence) were four times more likely to report better mental health status than Canadian-born residents, but this advantage decreased over time. |
| **Lou, 2005 (Canada) (32)** | The CCHS, Cycle 1.2, in 2002<br><br>(Cross-sectional study) | Canadian-born and immigrants (ages 15 years and older) who lived in private dwellings in 10 provinces (ages 15 years and older; N= 36,984) | Immigrant status and time of residence | Self-reported mental health status | Recent immigrants (0-9 years) were 57% less likely to have poor mental health vs Canadian-born. No difference in self-reported mental health was found between long-term immigrants (resided > 10 years) and Canadian-born. |
| **Ali, 2002 (Canada) (31)** | The CCHS, Cycle 1.1 from 2000 to 2001<br><br>(Cross-sectional study) | Canadians in all provinces (ages 15 to 75 years; N= 131,000) | Immigrant status and time of residence | Self-reported depression episode in the last year and alcohol dependence | Immigrants had lower rates of depression and alcohol dependence than the Canadian-born population. Among immigrants, those who arrived in Canada recently (< 5 years) had the lowest rates. Long-term immigrants (10-14 years or > 20 years) reported the same rates of depression as the Canadian-born. Proficiency in English or French were not related to immigrants' lower rates of depression. |
| *United States (U.S.) studies* | | | | | |
| **Wilmoth, 2003 (U.S.) (8)** | The Health and Retirement Study from 1992 to 1994<br><br>(Retrospective cohort study) | Immigrants and non-immigrants (ages 51 to 61 years old; N= 6,391) | Immigrant status, time of residence, and living arrangement | Depressive symptoms (CES-D) | Immigrants had more depressive symptoms than non-immigrants, particularly if they lived alone. Immigrants and non-immigrants who were depressed at baseline had higher depressive symptoms at the 2-year follow-up. Immigrants had greater increases in depressive symptoms over time than non-immigrants. |
| **Ikonte, 2020 (U.S.) (30)** | The National Health Interview Survey data from 2010 to 2016<br><br>(Cross-sectional study) | Adults (ages 18 years or older; N= 101,142) | Immigrant status and time of residence | Depression and serious psychological distress (K6) | Immigrants were 11% less likely to be depressed compared to US-born. Prevalence of depression increased in immigrants as time of residence increased. |

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| | | | *European Studies* | | |
| **Helgesson, 2019 (Sweden) (45)** | The National registers at Statistics Sweden and the Swedish National Board of Health and Welfare, follow-up of 18 years<br><br>(Retrospective cohort study) | Labour migrants (Western, ages 18 to 47 years; N= 14,199 and refugee/family reunion (non-Western) migrants, n=60,755 to Sweden in 1985-1990; ages between 18 and 47 years from 6 selected regions compared with an age-matched and gender-matched group of native Swedes (N= 1,405,047); followed for three consecutive 6-year periods (1991-1996, 1997-2002 and 2003-2008) | Western and non-Western migrant status | Psychiatric disorders, cardiovascular disease and mortality | Western migrants vs native Swedes had lower or equal hazard ratios for all studied outcome measures during all time-periods indicating a healthy immigrant effect in that group. Non-Western migrants vs native Swedes had higher or equal HRs for all studied outcomes except for mortality during all time periods of follow-up. |
| **Ronda-Pérez, 2019 (Spain) (29)** | The Longitudinal Studies on Immigrant Families Project study in 3 waves 2015, 2016 and 2017<br><br>(Retrospective cohort study) | Original dataset included 250 families (ages 18 years and older; N= 473); immigrants (N= 359) and natives (N= 107) from 2 regions in Spain | Immigrant status and time of residence | Common mental health disorders (GHQ-12) | Immigrant workers (< 15 years in Spain) had lower risk of developing common mental health disorders than Spanish-born workers. |
| **Gkiouleka, 2018 (Europe) (39)** | The European Social Survey and the Greek survey, 7 rounds in 2014<br><br>(Cross-sectional multi-country study) | Immigrants and non-immigrants across 21 countries (ages 25 to 65 years old; N= 22,775) | Immigrant status | Depressive symptoms (CES-D) | Migrants had higher depressive symptoms vs non-migrants in less than half of the examined countries (Switzerland, Germany, Denmark, France, the Netherlands, Norway, Poland, and Sweden) except for Greece and the UK. 2nd generation migrants were more vulnerable to depressive symptoms than the 1st generation. |
| | | | *Australian Studies* | | |
| **Demutska 2021 (Australia) (194)** | Convenience sample recruited through online survey<br><br>(Cross-sectional study) | Russian-speaking skilled immigrants and non-immigrants residing in Former Soviet Union, Australia, Russia, Ukraine, or Belarus (N= 193, mean age 35 ± SD 6.0) | Immigrant status and language | Depression (CES-D) and anxiety symptoms | Results indicated that levels of anxiety and depression were higher in Anglo-Australians compared to the Russian-speaking immigrant and the Russian-speaking non-immigrant groups after controlling for age, gender, relationship status, highest educational level, employment and health status. |

## Ethnicity and mental health disparity

Differences in depressive symptoms and mental health outcomes among ethnic and cultural backgrounds have been reported in the immigrant population (162, 164, 195-207). These differences were mostly observed by U.S. studies with a focus on the Hispanic (162, 196, 197, 199, 200, 202), Asian (198, 199, 202-204), Arab and African American groups (164, 195, 204). I summarized these studies in Table 2. For example, in one U.S. study conducted by Alegría and colleagues (2008) using the NLAAS and the National Comorbidity Survey Replication, Puerto-Rican participants experienced comparable rates of mood, anxiety and substance disorders than non-Latino Whites whereas Mexicans experienced lower rates (162). In another U.S. study using the National Epidemiological Study of Alcohol and Related Conditions survey (2001-2006), Breslau and colleagues (2009) found a lower risk of mood and anxiety disorders only among immigrants who spent their adolescent years outside of the U.S. compared to participants born in the U.S. (208). Based on a cross-sectional analysis of the Hispanic Established Population for the Epidemiological Study of the Elderly (2004-2005; 75 years and older), Gerst and colleagues (2010) found that Mexican immigrants in the U.S. had higher depressive symptoms than U.S.-born Mexican Americans (196). Jamil and colleagues (2008) conducted a cross-sectional health survey in 2008 to compare self-reported depression in Arab Americans, Chaldean-Americans, and African-Americans. Arab-American participants reported the highest rates of depression and Chaldean-Americans the lowest rate (195). Similarly, Williams and colleagues (2007) found differences in mental health outcomes by ethnicity in a descriptive analysis of the U.S. National Survey of African American Life. African American females had higher risks for 12-month and lifetime psychiatric disorders compared to Caribbean American females (164). When comparing immigrant Asian females with U.S.-born females of Asian origin using the NLAAS study (2002-2003), being an immigrant female was strongly associated with lifetime psychiatric disorders (209). Alvarez and colleagues (2018) found that individuals with foreign-born parents were less likely to have lifetime risks of Diagnostic and Statistical Manual of Mental Disorders (DSM) anxiety, mood, and substance use disorders in a nationally representative sample of four U.S. surveys (202). *These results suggest that the impact of immigration on depressive symptoms differs by ethnic or racial background, sex, nativity (for individual or parents), and age at immigration. I did not find any Canadian study that explored the risk of depression in immigrants by their ethnical background.*

Table 2. Summary of the studies showing depressive symptoms in ethnic groups

| Author, year of publication, (Country) | Data source (Study design) | Study population | Exposure | Outcome | Findings |
|---|---|---|---|---|---|
| **Guo, 2019 (United States, U.S.) (203)** | The Population Study of Chinese Elderly (PINE) from 2011 to 2013<br><br>(Cross-sectional study) | Chinese community-dwelling older adults in Chicago (ages 60 years and older; N= 3,138) | Age at migration (young adult < 35; adult 35-49; midlife 50-64; and later life 65+ years) | Depression (PHQ-9) and self-reported quality of life (QoL) | Migrating in later life was associated with more depressive symptoms, but also higher chance of reporting good quality of life. Late-life immigrants' greater depression was partially attributed to low income, lack of access to health care, poor physical health, and weak social relations. Participants who migrated at later life had higher risk of depressive symptoms than participants who migrated in young adulthood or adulthood but more likely to report good/very good QoL. |
| **Alvarez, 2019 (U.S.) (202)** | Four surveys: the National Comorbidity Survey-Replication, the National Latino and Asian American Study (NLAAS), the National Survey of American Life, and the National Comorbidity Survey Re-Interview from 2001 to 2003<br><br>(Cross-sectional study) | Respondents (ages 18 years and older; N= 21,024) | Nativity status (5 categories), parental nativity, and race/ethnicity | Mood disorders, anxiety and substance use disorders (DSM-IV) | Asians had the lowest lifetime prevalence of mental health disorders (23.5%), followed by Blacks (37.0%), Latinos (38.8%), and Whites (45.6%). Risk of disorder onset was lowest for foreign-born respondents in years before migration. Odds of mood disorder onset were higher for Whites with at least one U.S.-born parent. |
| **Budhwani, 2014 (U.S.) (204)** | The Collaborative Psychiatric Epidemiology Surveys from 2001 to 2003<br><br>(Cross-sectional study) | Immigrants, American-born non-Whites and American-born Whites (ages 18 years and older; N= 17,249) | Immigrant status and ethnicity | Lifetime major depressive disorder (DSM-IV) | Asian and Afro-Caribbean immigrants had lower odds of depression vs non-immigrant counterparts. |
| **Lau, 2013 (U.S.) (201)** | The NLAAS from 2001 to 2003 | Immigrant Asian American women compared to U.S.- | Nativity status and age at immigration | Any depressive disorder (DSM-IV) | U.S.-born women were twice as likely as late-life immigrants to report lifetime history of depression and anxiety. Later life immigrants had a higher |

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| | (Cross-sectional study) | born Asian American women (mean age 35 years; N= 2,069) | | | prevalence of depressive disorder than early-life immigrants. |
| **Casillas, 2012 (U.S.) (200)** | The Multi-Ethnic Study of Atherosclerosis (MESA) from 2000 to 2002<br><br>(Cross-sectional study study) | Latinos-overall, Mexicans-only and Other-Latinos (non-Mexicans) (ages 45 to 84 years; N= 1,429) | Nativity and time of residence | Depressive symptoms (CES-D) | Foreign-born Latinos had similar or higher scores of depressive symptoms vs U.S.-born Latinos. These associations were similar within the Mexican-only group. |
| **John, 2012 (U.S.) (199)** | The NLAAS from 2002 to 2003<br><br>(Cross-sectional study) | Asian respondents (ages > 18 years; N= 1,530) | Nativity, English language proficiency and acculturative stress | Any mental health disorder in past 12 months, any anxiety disorder in past 12 months and any depressive disorder in past 12 months (DSM-IV) | Immigrants vs U.S.-born Asians had worse socioeconomic profiles, increased odds for fair/poor mental health and decreased odds for any DSM-IV mental disorder and anxiety. Speaking fair/poor English was strongly associated with worse outcomes. |
| **Bernstein, 2011 (U.S.) (198)** | A convenience sample of Korean immigrants living in New York city in 2008<br><br>(Cross-sectional study) | Korean immigrants (ages 18 years and older; N= 304) | Acculturative stress, discrimination and English language proficiency | Any depressive symptoms (CES-D) | Korean immigrants were at twice the rate of depression (13.3%) compared to.the general U.S. population. High discrimination levels and low English language proficiency were associated with higher risks for depression, but acculturative stress was not associated with depression. |
| **Breslau, 2011 (U.S.) (197)** | Population surveys in the U.S. and Mexico from 2001 to 2003<br><br>(Cross-sectional study) | Non-migrant family members (N= 2,519) of migrants in Mexico and Mexican migrants in the U. S. (ages 18 to 65 years old; N= 554) | Immigrant status | First onset of any depressive or anxiety disorder (WMH-CIDI) | After arrival in the U.S., migrants had 42% higher risk for first onset of any depressive or anxiety disorder vs non-migrant family members of migrants in Mexico. Risk was higher in those aged 18-25 or 26-35 years at interview post-migration. |
| **Gerst, 2010 (U.S.) (196)** | The Hispanic Established Population for the Epidemiological Study of the Elderly (Hispanic EPESE) from 2004 to 2005<br><br>(Cross-sectional study) | Non-institutionalized Mexican American men and women (ages 75 years and older; N= 1,699) | Nativity status (Mexico-born vs U.S.-born) | Depressive symptoms (CES-D) | Elders born in Mexico had higher odds of depressive symptoms vs U.S.-born Mexican Americans. Age at arrival, sex and other covariates did not modify that risk. |

| | | | | | |
|---|---|---|---|---|---|
| **Jamil, 2008 (U.S.) (195)** | The Arab American and Chaldean Council and Wayne State University School of Medicine survey in 2005<br><br>(Cross-sectional study) | Immigrants with Arab, Chaldean, and African ethnic background (all age groups; N= 3543 adults) | Ethnicity | Self-reported depression | The highest rate of depression was found in Arab American participants (23.2%), then African Americans (15%) and Chaldeans (13.3%). Self-reported prevalence of depression by country of origin and religious affiliation differed significantly. |
| **Alégria, 2008 (U.S.) (162)** | The NLAAS and the National Comorbidity Survey Replication from 2001 to 2003<br><br>(Cross-sectional study) | Latino individuals (ages 18 years and older; N= 2,554) | Immigrant status | Psychiatric disorder (WMH-CIDI) | U.S.-born Latino subjects reported higher rates for most psychiatric disorders than Latino immigrants. Risk of most psychiatric disorders was higher for non-Latino White subjects than for Latino subjects. |
| **Williams, 2007 (U.S.) (164)** | The National Survey of American Life from 2001 to 2003<br><br>(Cross-sectional study) | Non-institutionalized U.S. Blacks (ages 18 years and older; N= 1,583) | Immigrant status, race/ethnicity and generation status ($1^{st}$,$2^{nd}$, $3^{rd}$) | Psychiatric disorders (DSM-IV) | Caribbean Black men (vs African American men) had higher risks for 12-month psychiatric disorders. African American women (vs Caribbean Black women) had higher risks for 12-month and lifetime psychiatric disorders. Risks varied by ethnicity, immigration history, and generation status within the Caribbean sample with $1^{st}$ generation Caribbean Blacks having lower rates of psychiatric disorders vs $2^{nd}$ or $3^{rd}$ generations. |

## Depression and screening tools

Several instruments have been developed and validated to assess depressive symptoms and mental health disorders in the population (210). These instruments are based on self-reported questionnaires and avoid costly clinical diagnostic assessments for depression. However, only few of them are sensitive to cross-cultural and age sub-group differences (211-213). Chorwe-Sungani and Chipps (2017) conducted a systematic review of screening instruments for depression (210). They found that seven of these instruments including Centre for Epidemiologic Studies Depression Scale (CES-D-10) (214) and Kessler Psychological Distress Scale 10 (K10) to be widely accepted (215, 216).

The 10-item CES-D-10 is commonly used to measure depressive symptoms in non-clinical populations (217). Irwin and colleagues (1999) found that the CES-D-10 had a sensitivity of 100% and specificity of 93% for identifying major depression in adults (mean age ± SD: 44.9 ± 10.3 years) as compared to DSM-V assessment (218). In addition, based on its psychometric properties and internal consistency, CES-D-10 has been found to be a reliable and valid measure of depression in healthy community dwelling older adults (214, 219). Andresen and colleagues also showed good predictive accuracy (kappa 0.97, $P < 0.001$) for CES-D-10 when compared to the full item scale, CES-D-20 (1994) (214).

Kessler and colleagues (2003) developed the 10-item distress feeling questionnaire to screen for serious mental illness as defined by any 12-month DSM-IV disorder with a Global Assessment of Functioning score of less than 60; the area under the receiver operating characteristic curve (AUC) was 0.85 for K10 (216). K10 also performed efficiently in terms of time and cost when compared to the WHO Composite International Diagnostic Interview (CIDI) and DSM-IV (216). K10 is also commonly used to measure depressive symptoms in non-clinical populations (217). Based on DSM-V criteria, Vasiliadis and colleagues (2015) found that a cut-off of 19 in the K10 scale would have an AUC of 0.77 and 0.83 for detecting minor and major depression, respectively (220). As reported by several studies, individuals with a K10 score of ≥ 19 were considered to be likely experiencing subclinical symptoms of depression that required medical attention to prevent

worsening (220-224). However, validity of the K10 and CES-D-10 scales in Canadian immigrant groups have not been assessed.

## Depression, diabetes, and immigrant status

Immigrants have been reported to be at higher risk for developing diabetes than non-immigrants because of higher genetic susceptibility and resettlement-associated lifestyle changes (225, 226).

In Canada, an increasing proportion of immigrants are of South-Asian, the Caribbean, Latin Americans and sub-Saharan Africans origins (11, 227, 228). Immigrants to Canada from these regions were found to have two to three times higher risks of developing type 2 diabetes than the native-born Canadian population (11, 72, 227), and to develop diabetes at an earlier age than immigrants from Western Europe and North America (20-40 vs 35-49 years of age, respectively) (71).

The lifestyle changes dictated by the resettlement process in immigrants have resulted in increased unhealthy eating habits in immigrants as shown by Misra and Ganda (2007) (229) and a "nutrition transition" from diets rich in fruits and vegetables to diets rich in processed food, fat, sweets and salt (11, 72, 73, 227). Unhealthy diets and poor eating habits compounded with a more sedentary lifestyle increase the risk of weight gain and hasten the development of insulin resistance, chronic inflammation, and diabetes (230-233). This phenomenon of health decline in immigrants following their arrival has been reported in Canada (64, 69, 71) and elsewhere (89, 234). In an analysis of the CCHS (2007-2008) data, Betancourt and Roberts (2010) found that Canadian immigrants were at 20% higher risks of diabetes when compared to Canadian-born individuals (72) with the risk varying by ethnicity (11, 72, 77, 227), age at arrival, and time of residence (Table 3).

The co-occurrence of depression and diabetes is high in the Canadian population with diabetes possibly increasing the risk of depression and depression increasing the risk of diabetes (94, 95, 97, 235). This dual relationship between diabetes and depression has not been studied in the immigrant population. Co-occurrence of diabetes and depression is important to evaluate in immigrants because it reveals increased health burden and complications in a vulnerable group that makes over 22% of the Canadian population and impacts the country's health system expenditure (89, 90). Based on the U.S. Medical Expenditure Panel survey (2004-2014), the co-

occurrence of diabetes and depression was associated with double the expenditure for diabetes alone (USD $20,000 vs $10,000) in the population and with five times these expenditures in older patients (236).

Anderson and colleagues (2001) summarized 20 cross-sectional studies in a meta-analysis and found that the odds of depression in individuals with diabetes (any type) was twice that of those without diabetes (235). In a meta-analysis including controlled studies with at least 50 individuals in each of the diabetes and control groups, Ali and colleagues (2006) reported higher prevalence of depression in patients with (vs without) type 2 diabetes (17.6 vs 9.8%, OR 1.6, 95% CI: 1.2-2.0) (95). The prevalence estimate of depression was higher in females (23.8%) than males (12.8%), but diabetes-associated risk increase was lower in females (OR 1.3, 95% CI: 1.2–1.4) than males (OR 1.9, 95% CI: 1.7–2.1). In a systematic review by Roy and colleagues (2012) including studies of various designs (cross-sectional, cohort, prevalence and clinical trials), the prevalence of depression was nearly twice as high in people with type 2 diabetes compared to those without diabetes (19.1%, range 6.5-33% vs 10.7%, range 3.8-19.4%). Females with diabetes as well as those without diabetes, had higher prevalence of depression than their male counterparts. The reviewed longitudinal studies provided support for a modest relationship between diabetes and depressive symptoms, but the exact direction of this relationship (i.e, the depression's role as a risk factor or consequence of diabetes) was not examined (97). Another systematic review conducted by Renn and colleagues (2011) including 14 cross-sectional, cohort and review studies (2000-2010) arrived to a similar conclusion on the existence of a relationship between depression and diabetes, but with unclear direction (94).

Knol et al. (2006) sought to examine whether depression increases the risk of diabetes by conducting a meta-analyses of longitudinal studies examining this issue (237). Based on nine empirical studies with follow-up time ranging from 3 years to 16 years and published between 1966 and 2005, they concluded that among adults with normal blood glucose levels at baseline, those with either a depression diagnosis or high depressive symptomatology had a 37% increased risk of developing type 2 diabetes compared to those with no or little depressive symptomatology (237).

A meta-analysis by Mezuk and colleagues (2008) included 13 prospective studies from 1996 to 2007 and looked at the bidirectional relationship between diabetes and depression. Individuals with type 2 diabetes had a 15% increased risk of depression compared to those without diabetes and depression and/or depressive symptomatology increased the risk of type 2 diabetes by 60% (92). More recent systematic review (238) and meta-analyses (239, 240) examined the longitudinal associations between diabetes status and the risk of depression and between the depression status and the risk of diabetes in the general population. Reviewed studies provided support for a modest relationship between diabetes status and the occurrence of depressive symptoms and a more robust association between depression status and diabetes incidence. In a meta-analysis (240), Zhuang and colleagues (2017) reported that individuals with (vs without) depression were at 34% higher risk for diabetes (OR 1.34, 95% CI: 1.23-1.46); this relationship was stronger in males (OR 1.63, 95% CI:1.48-1.78) than in females (OR 1.29, 95% CI: 1.07-1.51). They also showed that individuals with (vs without) diabetes were at 28% higher risk of depression (OR 1.28, 95% CI:1.15-1.42); the authors did not examine this risk by sex (240).

In summary, the available literature supports the existence of an increased risk of diabetes among individuals with depression and a possible increased risk of depression among individuals with diabetes. However, evidence was based on combined results from studies with various designs and unclear temporal relationship between diabetes and depression. *My search did not identify any study that examined the bidirectional relationship between diabetes and depression in immigrants.*

Table 3. Summary of the studies showing depression and diabetes in immigrants compared to non-immigrants

| Author, year of publication (Country) | Data source (Study design) | Study population | Exposures | Outcome | Findings |
|---|---|---|---|---|---|
| **Morales, 2021 (U.S.) (89)** | The National Health Interview Surveys (NHIS) from 2006 to2015<br><br>(Cross-sectional study) | Adult participants (ages ≥ 18 years; N= 33,452) | Self-reported diabetes | Self-reported Depressive symptoms | Co-morbid diabetes and depression in immigrants is comparable to that found in U.S. born populations (0.78% vs 0.74%, respectively). Being a woman, poor, and from specific regions in Latin America are associated with a higher odds of comorbid diabetes and depression. |
| **Kim, 2017 (U.S.) (241)** | Secondary data from clinical trial of a community-based self-help intervention from 2009 to 2014 compared with National Health and Nutrition Examination Survey data from 2005-2012 cycles<br><br>(Cross-sectional study) | Korean Americans and Americans with or without diabetes (mean age 58 years; N= 250) | Diabetes | Depression (PHQ-9) | More Koreans had depression (44.2%) than did Americans (28.7%) with diabetes or without diabetes (20.1%). Significantly more Koreans with diabetes had mild (29.3%) or clinical (14.9%) depression than did Americans with diabetes (mild, 17.2%; clinical, 11.5%) or without (mild, 13.8%; clinical, 6.3%). |
| **Downer, 2016 (U.S.) (242)** | The Hispanic Established Population for the Epidemiological Study of the Elderly collected waves in 1993, 2005, 2007 and 2010<br><br>(Cross-sectional study) | Mexican Americans residing in five southwestern states: Texas, New Mexico, Colorado, Arizona, and California (ages > 75 years; N= 1,785) | Diabetes, diabetes medication and depressive symptoms (CES-D) | Disability, and mortality | Diabetics were more likely to become disabled in activities of daily living (ADL; Hazard Ratio, HR 1.44, 95% CI: 1.18-1.77) and deceased (1.47, 1.24-1.74) compared with non-diabetics. Diabetics reporting high depressive symptomatology were more than two times as likely to become ADL disabled and deceased compared with diabetics not reporting high depressive symptoms. Participants with high depressive symptoms and taking insulin alone or both oral medications and insulin were at the greatest risk of disability (3.83, 1.66-8.81). |
| **Muñoz, 2014 (U.S.) (81)** | Convenience sample in Puebla, Mexico from 2010 to 2011 compared to a convenience sample in Chicago, U.S. in 2010<br><br>(Cross-sectional study) | Mexico women with diabetes and U.S. Mexican descent women (ages 18 to 60 years; N= 362) | Diabetes | Depressive symptoms (CES-D) | The Chicago women reported higher levels of depression than the Puebla sample (38% versus 17%). Among those with comorbid depression and diabetes in both sites, minimal variations in symptoms were observed. Depressive symptoms (specifically feeling sad) and symptoms associated with diabetes (fatigue and sleep problems) were heightened in both groups. |

## Mental healthcare utilization and access in Canada

The Canada Health Act governs provision of health services in Canada and ensures that primary care doctors, hospitals, and specialists are available to all people (90). The Act prescribes that an individual's medical needs will be treated regardless of income, employment status, or province. To obtain health care access, the services need to be first available, timely, and delivered equitably. Despite the present law, evidence suggested that access to physical and mental health services is still problematic (23, 243, 244). In Canada, attachment to a usual provider of care, such as a family doctor, is crucial to properly screen for mental illnesses, to make referrals, and to follow patients for their adherence to treatment (44, 69, 245). *The shortage in family physicians and the loaded schedule of these physicians hinders the possibility of screening for mental health disorders in general and more so among immigrants (23, 87, 246).*

Immigrants experience additional barriers to mental health care than the general population (243, 247, 248). These barriers have included language, attitudes towards medical technology and treatment options, racial discrimination, and lack of knowledge of the system (11, 58, 155, 157, 191, 192, 249-251). Misconceptions and mistrust can also negatively affect medical consultation or follow-up (27, 252, 253). In the LSIC wave 3 (2005), one in four Canadian immigrants who experienced a health decline reported problems accessing health services (161). While barriers to accessing care may be more acute for immigrants (22), self-reported unmet needs among immigrants do not always reflect this reality. In an analysis of CCHS data (2000-2001) including people ages 18 years and older, Wu and colleagues (2005) found that immigrants in Canada had 12% lower all-cause unmet needs than non-immigrants (155). However, as mentioned previously, unmet needs are only measured in those who seek care and rates are affected by expectations, cultural differences in disclosure and fear of stigma and discrimination (24, 54, 55, 57, 254-257).

Differences in attempts to utilize mental healthcare services between immigrants and non-immigrants are poorly understood. I have summarized the studies that examined mental healthcare utilization in immigrants in Table 4 (33, 38, 49-54). All these studies agreed that utilization of mental healthcare services was lower amongst immigrants compared to non-immigrants. For example, a study by Kirmayer and colleagues (2007) that surveyed immigrants and non-

immigrants recruited at a Montreal clinic (54), reported a 3-fold lower rate of health services utilization for psychological distress in immigrants (5.5%) compared to non-immigrants (14.7%). This difference in rates was not explained by sociodemographic, somatic or psychological depressive symptoms, time of residence in Canada or alternative sources of help. Also, when evaluating the 12-month use of mental health care services using the CCHS databases in 2003, Tiwari and colleagues (2008) found that Asian immigrants (ages 15 years and older) were less likely to use the mental health care services compared to White individuals in Canada (258). Similar results were previously reported by Chen and colleagues (2005) among Chinese immigrants in British Columbia between 1985 and 2000 (259). Studies conducted in other countries also showed lower use of services for depression in immigrants. For example, in a study conducted in Finland using a registry database in 2010, Kieseppä and colleagues (2021) found that immigrants (ages 15 years and older) received less intensive and less often treatment for depression and anxiety disorders compared to the Finish-born population (26). Immigrants' communication challenges, cultural behaviors or stigmatisation may explain these finding (24-28, 55, 56, 260). *Lack of seeking mental health care for depressive symptoms delay diagnosis until more severe symptoms develop which increases the risk for complications and may lead to long-term physical and mental problems.*

Sex differences have also been reported in perceived mental health and self-reported diagnosis of mood disorders. In a study conducted in Alberta by Salami and colleagues (2017) using mixed-methods, immigrant females were more likely to report poor mental health compared to immigrant males (33). Qualitative studies have also indicated that immigrant females reported having unmet health needs (261) and lack of satisfaction in the care they received (262). However, similar to the general immigrant population, quantitative studies found higher reports for unmet needs among the Canadian-born females compared to immigrant females. In an analysis of the 12-year Canadian NPHS databases, Setia and colleagues (2011) found that unmet needs in the past 12 months were reported by 68% fewer non-white immigrant females compared to Canadian-born females (263). Similarly, Dunn and Dick (2000) and Wu and colleagues (2005) reported fewer unmet health care needs in immigrant females compared to their Canadian-born counterparts (44, 155). *The disparity in mental healthcare utilization between immigrants and non-immigrants is not clearly understood. While immigrants may have greater needs for mental health care services, their*

*utilization of these services have been found to be lower than that of the general population. Additional longitudinal studies are needed to help clarify this issue and identify factors associated with mental healthcare utilization among immigrants.*

Table 4. Summary of the studies showing mental healthcare utilization in immigrants compared to non-immigrants

| Author, year of publication (Country) | Data source (Study design) | Study population | Exposures | Outcome | Findings |
|---|---|---|---|---|---|
| **Gaigl, 2022 (Germany) (49)** | Multi-centric study of the Implementation status of the German guideline for psychosocial interventions for patients with severe mental illness in 2019<br><br>(Cross-sectional study) | Immigrants and non-immigrants inpatients and day hospital patients of psychiatric settings (ages 18 to 65 years; N= 387) | Immigrant status | Treatment satisfaction, needed and received mental healthcare and se of mental healthcare | Migrant patients were more satisfied with the overall treatment in the past year compared to non-migrant patients. No differences between both groups were identified in met and unmet treatment needs and use of supply services (psychiatric, psychotherapeutic, and psychosocial treatment). |
| **Kurdyak, 2021 (Canada) (50)** | Health care administrative data collected from 2010 to 2018<br><br>(Retrospective cohort study) | Individuals with an incident psychiatric emergency department visit (ages 16 years and older; N= 659,084) | First emergency department visit | Outpatient mental health or addictions contact at 2 years preceding the incident emergency department visit | Increased odds of first-contact emergency department visits included older, male, immigrants (vs non-immigrants), rural residents, and in those with minimal primary care. |
| **Kieseppä, 2021 (Finland) (26)** | Register-based sample by the Finnish Institute for Health and Welfare and hospital administrative database from 2010 to 2015<br><br>(Cross-sectional study) | Immigrants (N= 5,250) and Finnish-born controls with depression (ages 15 years and older; N= 7,114) | Immigrant status | Treatment intensity for depression | Immigrants more often received lower intensity treatment and less often higher intensity treatment. These differences were most striking among those from Eastern Europe, the Middle East, and Africa. Immigrants with depression or anxiety have lower psychiatric comorbidity than natives. |
| **Olsson, 2021 (Sweden) (51)** | Questionnaire and register data in 2008<br><br>(Cross-sectional study) | Individuals in a random population-based sample from western Sweden (ages 19 to 64 years; N= 3,987) | Country of birth, gender and education | Unmet need and perceived need | Men were less likely to perceive need for care and to seek care. People with secondary education were less likely to seek care than those with university education. There were no statistically significant differences based on country of birth. |
| **Salami, 2019 (Canada) (33)** | Interviews and focus groups in Alberta from 2016 and 2017<br><br>(Qualitative study) | Immigrant service providers' perceptions of access to and use of mental health services for | Barriers to access and use of mental health services | Strategies to improve mental health service delivery | Barriers include language barriers, cultural interpretations of mental health, stigma around mental illness, and fear of negative repercussions when living with a mental illness. Strategies include developing community-based services, attending to financial |

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| | | immigrants and refugees (N= 53) | | | barriers, training immigrant service providers on mental health, enhancing collaboration across sectors in mental health service delivery, and advancing the role of interpreters and cultural brokers. |
| **Abebe, 2017 (Norway) (52)** | The Norwegian Patient Registry and Statistics Norway form 2008 to 2011<br><br>(Cross-sectional study) | 3.3 million ethnic Norwegians and 200,000 immigrants from 11 countries (ages < 60 years) | Country of origin | Use of specialist mental healthcare services | Among adult immigrants, specialist mental healthcare services utilization rates were generally lower than among ethnic Norwegians, particularly those from Poland, Somalia, Sri Lanka, and Vietnam. Adult immigrants from Iraq and Iran, however, had high utilization rates. |
| **Derr, 2016 (U.S.) (53)** | Systematic Review of 62 articles by using a structured abstracting form<br><br>(Systematic review) | Mental health service utilization among immigrants to inform future research efforts addressing disparities in access to care | Immigrant status | Mental health service use | Immigrants from Asia, Latin America, and Africa use mental health services at lower rates than nonimmigrants, despite an equal or greater need. Lower usage has been found to be more pronounced among men, the uninsured, and the undocumented. |
| **Tiwari, 2008 (Canada) (258)** | The Canadian Community Health Survey (CCHS) in 2003<br><br>(Cross-sectional study) | South Asian, Chinese, White, and Black residents of Ontario (ages 15 years and older; N= 254,951) | Ethnicity | Mental health services use and unmet needs | Asian immigrants are less likely to use mental health services than White individuals. |
| **Kirmayer, 2007 (Canada) (54)** | Telephone survey of random samples from a Montreal clinic in 1995<br><br>(Cross-sectional study) | Canadian-born individuals (N=924) and immigrants (mean age ± SD, 44.1 ± 17.3; N= 776) | Somatic symptoms, psychological distress, and recent life events | Mental health services use | Rates of use of health care services for psychological distress were significantly lower among immigrants (5.5% compared with 14.7%, $P < 0.001$). The lower rate of use by immigrants could not be explained by differences in sociodemographic, somatic or psychological symptoms, length of stay in Canada, or use of alternative sources of help. |
| **Whitley, 2006 (Canada) (23)** | Face-to-face in-depth interviews<br><br>(Qualitative study) | West Indian immigrants in Montreal (N= 15) | Barriers of use | Healthcare use | Three factors explaining their reluctance to use mental health services: perceived over-willingness of doctors to rely on pharmaceutical medications as interventions, dismissive attitude and lack of time from physicians, and personal beliefs of nonmedical interventions. |
| **Chen, 2005 (Canada) (259)** | Administrative databases from British Columbia (BC)<br><br>(Cross-sectional study) | Chinese immigrants who landed in BC between 1985 and 2000 (all ages; N= 150,000) | Immigrant status | Mental health visits and hospitalization | Chinese immigrants use less overall health care than controls, the difference in utilization rates is particularly pronounced with regard to mental health problems, especially for visits to psychiatrists and psychiatric hospitalization/ |

## Cohort studies and loss to follow-up

Including immigrants and vulnerable populations in large cohort studies can improve our understanding and evaluation of immigrant health and healthcare utilization, population trends, and policies. High-quality population-based prospective cohort studies such as the Canadian Longitudinal Study on Aging (CLSA) are important to evaluate health inequities and trajectories in ageing immigrants and non-immigrants (105). In longitudinal cohort studies such as the CLSA, loss to follow-up, non-compliance, or other obstacles to research may modify the cohort composition and lead to biased results if not well-addressed in the analyses (99-104, 264). Previous studies have found that participants with mental illnesses are at higher risk of dropping out of cohort studies (101, 106, 107).

Several prospective observational studies and randomised controlled trials have shown that unbalanced loss to follow-up in two comparison groups can lead to biased estimates of association (109, 265). A large scale meta-analysis of cohort studies assessing immigrant mortality found that 29% of the studies identified loss to follow-up as an issue (135). I summarized the cohort studies reporting on loss to follow-up in immigrant compared to non-immigrants in Table 5 (264, 266-268). One study from Canada and two from Europe found immigrants to be at higher risk of dropping out from longitudinal studies than non-immigrants (264, 266, 267), while another U.S. study found comparable rates (268). In Canada, Vyas and colleagues (2021) conducted a population-based retrospective cohort study (ages 55 years and older) using linked patient registry data with administrative health data (264). Adults with a first-ever diagnosis of ischaemic stroke, cancer or schizophrenia between 2002 and 2013 were identified in the patients' registries and followed to their index event (death, loss to follow-up or end of the study in 2018). Results showed that immigrants were more likely to be lost to follow-up than long-term residents which led to overestimation of the results (264). Another study in Sweden by Canivet and colleagues (2020) found that being born abroad (ages 18 to 80 years) was associated with higher risks of loss to follow-up and having poor health outcomes in the Scania Public Health Cohort (266). A study in France by Lanoy and colleagues (2006) also reported higher loss to follow-up among immigrants with HIV (ages 15 years and older) (267). Conversely, an older study by Wadsworth (1992) that followed a birth cohort from England, Wales and Scotland from 1946 to 1989 found comparable

rates of drop-outs for immigrants to the national population of the same age (268). *These methodological challenges need to be accounted for in the analyses of cohort studies.*

Table 5. Summary of the studies showing loss to follow-up in immigrants compared to non-immigrants

| Author, year of publication (Country) | Data source (Study design) | Study population | Exposures | Outcome | Findings |
|---|---|---|---|---|---|
| **Vyas, 2021 (Canada) (264)** | Three databases: the Ministry of Immigration, Refugee and Citizenship, the Death registry to (end-date 2018) and Administrative databases for any contact with health system.<br><br>(Retrospective cohort study) | Adults with a first-ever diagnosis of ischaemic stroke, cancer or schizophrenia between 2002 and 2013 from index event to death, loss to follow-up, or end of follow-up in 2018 (ages 55 years and older; N=389,777) | Immigrant status: immigrants are those arrived after 1985, and long-term immigrants as those arrived before 1985 and born outside of Canada. | All-cause mortality and loss to follow-up | Immigrants were more likely to be lost to follow-up than long-term residents in all disease cohorts. Not accounting for this loss to follow-up overestimated the magnitude of the association between immigration status and mortality in those with ischaemic stroke (Hazard Ratio (HR) of death before vs after accounting for censoring: 0.78 vs 0.83, ratio=0.95; 95% CI: 0.93-0.97), cancer (0.74 vs 0.78, ratio=0.96; 0.95-0.96), and schizophrenia (0.54 vs 0.56, ratio=0.97; 0.96 -0.98) |
| **Canivet, 2020 (Sweden) (266)** | The Scania Public Health Cohort Study linked to public registers on mortality and purchase of prescribed drugs from 1999 to 2009<br><br>(Retrospective cohort study) | Participants from the general population (ages 18 to 80 years; N= 23,437) | Determinants of health | All-cause mortality and loss to follow-up | Being born abroad, age (younger and older, versus middle-aged), male gender, low educational level, low self-rated mental, and general health and daily smoking were all related to dropping out. The 10-year mortality was higher among drop-outs (13.4% versus 11.9%; age-adjusted HR 1.6, 95% CI: 1.4–1.8). Being born outside of Sweden was associated with higher risks for all three poor health outcomes among participants, but not so among drop-outs. |
| **Lanoy, 2006 (France) (267)** | The French Hospital Database on HIV infection in 62 French University Hospitals belonging to 29 HIV treatment and information centers in 1998, 1999 and 2000<br><br>(Retrospective cohort study) | Participants with HIV (ages 15 years and older; N=34,835) | HIV | Loss to follow-up and mortality | Recent diagnosis of HIV infection were more likely to be lost to follow-up, as were patients without AIDS. Among recently diagnosed patients, loss to follow-up was more frequent among immigrants. |
| **Wadsworth, 1992 (England) (268)** | Random sample of all single, legitimate births cohort from 1946 to 1989<br>(Retrospective cohort study | Participants in the national registry (all ages; N=5,362) | Immigrant status | Response rates and death | Losses through death and emigration were comparable to those in the national population of the same age. High response rate is likely to be the result of home based data collections and of the regular contact. |

## PhD objectives

The overall goal of my thesis was to examine the health disparities in community dwelling middle-aged to older Canadian immigrants compared to non-immigrants in terms of depression and diabetes risks and the limitations of the longitudinal data used to study changes in immigrants' health over time.

The specific objectives of my thesis were to assess among community dwelling Canadian ages 45 to 85 years who participated in the Canadian Longitudinal Study on Aging (CLSA):

1. the risks of undiagnosed depression, persistent depressive symptoms and not seeking mental health care for these symptoms among immigrants and non-immigrants;
2. the effect of diabetes status on the risk of depressive symptoms at three years among immigrants and non-immigrants; and the effect of depressive symptoms on the 3-year incidence of diabetes among immigrants and non-immigrants;
3. the effect of immigrant status, depressive symptoms and language on the risk of loss to follow-up at three years.

## Chapter III: Data Source

The Canadian Longitudinal Study on Aging (CLSA) is a Canada-wide, study of community dwelling Canadians between the ages of 45 to 85 years at recruitment (269, 270).

The CLSA baseline data collection started in 2012 and was completed in 2015. Participants undergo repeated waves of data collection every three years for at least 20 years, or until death. In addition to the baseline and 3-year follow-up assessments, data collection is supplemented with a brief inter-assessment telephone interview, the Maintaining Contact Questionnaires (MCQ), to collect some additional data, update contact information, and minimize loss to follow-up.

CLSA participants were randomly selected from the population using three sampling frames (271): 1) a subset of Statistic's Canada's Canadian Community Health Survey-Healthy Aging (CCHS-HA); 2) the registries of provincial health care systems; and 3) Random Digit Dialing of landline telephones. For better representation of underserved people with less education and lower socio-economic status, efforts were made to over-sample in under-represented areas (269, 270). The overall participation rate for the CLSA was approximately 45%, and response rate was 10% (105). The CLSA excluded residents of the Canadian territories (Yukon, Nunavut and Northwest) and some remote regions including Federal First Nations reserves and other provincial First Nations settlements, full-time members of the Canadian Armed Forces, and institutionalized persons. Participants had to complete the questionnaires in either English or French and be physically and cognitively able to participate on their own (270). Participants who become institutionalized after baseline will continue to be followed until study completion, death, or loss to follow-up.

The CLSA includes two separate cohorts: the Comprehensive cohort and the Tracking cohort (269). The Tracking cohort includes 21,000 participants randomly selected across the ten provinces. For this cohort, all data were collected by computer-assisted telephone interviews administered through four sites, the University of Victoria, University of Manitoba, Université de Sherbrooke, and Dalhousie University, established across Canada to accommodate different time zones and language (English or French) requirements (270). The Comprehensive cohort includes 30,097 participants randomly selected within a 25-50 km radius from 11 sites in seven provinces:

Victoria, Vancouver and Surrey in British Columbia, Calgary in Alberta, Winnipeg in Manitoba, Ottawa and Hamilton in Ontario, Montreal and Sherbrooke in Quebec, Halifax in Nova Scotia, and St. John's in Newfoundland and Labrador. Data were collected through an in-person interview and on-site physical and cognitive assessments (105, 272). The Tracking and Comprehensive cohorts collected the same core demographic, social, physical/clinical, psychological, and economic data. In addition, the Comprehensive cohort participants undergo physical on-site measurements and provided biological specimens (blood and urine) at baseline. Sampling weights were calculated by CLSA for the combined Tracking and Comprehensive cohorts as well as for each one of these cohorts separately.

The CLSA data are available free of charge for PhD thesis projects. I obtained the baseline 18-month MCQ and 3-year follow-up data of the Tracking and Comprehensive cohorts for my PhD project. The physical assessment data were available at baseline, but not at the 3-year follow-up and the detailed medication data were not available at either time-point for my project.

## Chapter IV: Undiagnosed depression and persistent depressive symptoms and seeking mental health care

Preamble to Manuscript 1

My first study was conducted to shed light on the differences in the risks of undiagnosed depression, persistent depressive symptoms and seeking mental health care for these symptoms between community dwelling Canadian immigrants and non-immigrants ages 45 to 85 years. No previous study has examined the risks of undiagnosed depression and persistent depressive symptoms in immigrants.

I used the baseline and MCQ data of the CLSA Comprehensive cohort. I evaluated the presence of depressive symptoms at two time-points, baseline and 18 months. At baseline, I defined individuals to have undiagnosed depression as those who had a CES-D-10 score ≥ 10 and declared that they have not been diagnosed with depression by a health care professional in the previous year and were not taking any treatment for depression at that time-point. Among these, I identified those who also had depressive symptoms at 18 months using a K10 score ≥ 19 and labeled them as having persistent depressive symptoms at that time-point. I used the CES-D-10 score at baseline and the K10 score at 18 months as available in the CLSA data. As previously reviewed, both of these instruments have been found to be valid and reliable for the assessment of depression and depressive symptoms, respectively (214, 216, 219). Among those who had depressive symptoms at 18-month, I identified those who had self-reported that they saw a health care professional for these symptoms.

I considered the Andersen's behavioural model of access (273) to characterize baseline variables into predisposing, enabling and needs-related factors and personal lifestyle choices. I used multivariable logistic regression models to compare the risks of undiagnosed depression, persistent depressive symptoms and seeking mental health care for these symptoms between immigrants and non-immigrants while adjusting for baseline variables. I identified those predisposing, enabling, needs-related and personal lifestyle factors that were associated with each of my outcomes. To address the gap in knowledge regarding the association between time of residence and the risk of depressive symptoms in immigrants, I categorized time of residence in immigrants into less than

or equal to 5 years, 6 to 10 years, 11 to 20 years, 21 to 40 years and more than 40 years and compared the risks between these categories. I used separate logistic regression models to examine the effect of age (≤ 5 years, 6 to 10 years, 11 to 20 years, 21 to 40 years and more than 40 years) at immigration on undiagnosed depression and persistent depressive symptoms. However, because of the age of my study population (45 years and older) and the relatively small sample of immigrants in the CLSA Comprehensive cohort (N= 4,382), I was not able to study the dual effect of age at immigration and duration of residence.

My study was published in the journal of *Epidemiology and Psychiatric Sciences* on August 14th, 2020, and received the Best Paper of the Year as a trainee award from the *Réseau Québecois sur le Suicide, les troubles de l'Humeur et les troubles Asssociés* (RQSHA).

Farid D, Li P, Da Costa D, Afif W, Szabo J, Dasgupta K and Rahme E. Undiagnosed depression, persistent depressive symptoms and seeking mental health care: analysis of immigrant and non-immigrant participants of the Canadian Longitudinal Study of Aging. *Epidemiol Psychiatr Sci*. 2020;29:e158.

**Undiagnosed depression, persistent depressive symptoms and seeking mental health care: analysis of immigrant and non-immigrant participants of the Canadian Longitudinal Study of Aging**

Abstract

**Aims:** Early diagnosis and treatment of depression are associated with better prognosis. We used baseline data of the Canadian Longitudinal Study on Aging (2012-2015; ages 45-85 years) to examine differences in prevalence and predictors of undiagnosed depression between immigrants and non-immigrants at baseline and persistent and/or emerging depressive symptoms 18 months later. At this second time point, we also examined if a mental health care professional (MHCP) had been consulted.

**Methods:** We excluded individuals with any prior mood disorder and/or current anti-depressive medication use at baseline. Undiagnosed depression was defined as Center for Epidemiological Studies Depression 10 score ≥ 10. Depressive symptoms at 18 months were defined as Kessler 10 score ≥ 19. The associations of interest were examined in multivariate logistic regression models.

**Results:** Our study included 4,382 immigrants and 18,620 non-immigrants. The mean age (standard deviation) in immigrants was 63 (10.3) years versus 65 (10.7) years in non-immigrants and 52.1% versus 57.1% were male. Among immigrants, 12.2% had undiagnosed depression at baseline of whom 34.2% had persistent depressive symptoms 18 months later versus 10.6% and 31.4%, respectively among non-immigrants. Female immigrants were more likely to have undiagnosed depression than female non-immigrants (odds ratio 1.50, 95% confidence interval 1.25-1.80) but no difference observed for men. The risk of persistent depressive symptoms and consulting a MHCP at 18 months did not differ between immigrants and non-immigrants.

**Conclusions:** Female immigrants may particularly benefit from depression screening. Seeking mental health care in the context of depressive symptoms should be encouraged.

**Keywords:** Depression, Mental Health, Immigrant, National representative sample, Cohort, CLSA

## Introduction

Depression is associated with lower quality of life (224), higher risk of suicide (274-277), disability, and loss of productivity (179, 185, 278-283). Unfortunately, depression is often undiagnosed because of failure to recognize the symptoms and/or to seek mental health care (284-286). Delays in treatment are linked to lower remission and poorer prognosis (287, 288). In 2012, 50-67% of all cases of depression were undiagnosed in Canada (284).

Only around 40% of Canadians with mental health disorders seek mental health care (289). In particular, immigrants seem to underutilize mental health services (236, 290-294), despite the effect of migration on their mental health well-being (41, 42, 295-298). Immigrants differ from non-immigrants in their behavior towards healthcare seeking in general [predisposing (e.g. language barrier), enabling (e.g. employment, knowledge of healthcare system, community support), and needs factors (health status and perceived mental health)] (258, 299, 300), as described by Andersen's behavioral model of health services use (273, 301). The individual's willingness to seek care vary by their cultural shaping of symptoms, belief structures and illness behaviours (24, 302). Otherwise, structural barriers such as candidacy (migrants' eligibility for medical attention and intervention), lack of trust between patient and their physician, delayed diagnosis or under-referral can also diminish access to mental healthcare services in some immigrant groups (24, 302-304).

Over 20% of the Canadian population are immigrants (305). However, little is known about their risk of undiagnosed depression (UD) and about their mental health care seeking behaviours (7, 31, 42). These issues may be particularly salient in females who generally have higher rates of depression than males (176, 279, 306).

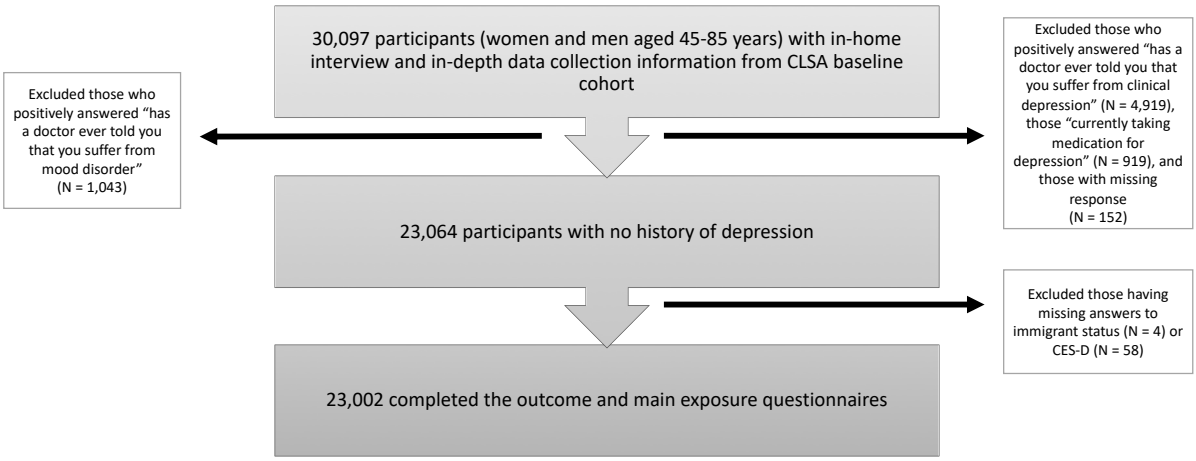
Some authors have examined the risk of depression in immigrants compared to non-immigrants (15, 41-43), but none examined the risk of UD in this group. Reviews that examined the risk of depression in immigrants reported inconclusive results (15, 307-310). Of note, moderating effects of length of stay in the host country, age at immigration, education attainment and employment status on risk of depression were reported (15, 41-43). Recently, one Canadian study found that the trajectory of deterioration in mental health for older immigrants is not linear with respect to length of stay (76) and further longitudinal investigation is needed.

Among Canadians who participated in baseline data collection of the Canadian Longitudinal Study on Aging (CLSA), Comprehensive cohort in 2012-2015 (ages 45-85 years), and who had not been previously diagnosed with any mood disorder and were not using an anti-depressive agent, we assessed associations between immigration status and the presence of UD at baseline. We also evaluated the association between immigration status and the presence of depressive symptoms (DS) at 18 months in those with and those without UD at baseline. In addition, we examined the association between immigration status and consulting a mental health care professional (MHCP) at 18 months among those with and those without DS at this time point and accounting for UD at baseline.

## Method

Between 2012 and 2015, for the baseline data of its Comprehensive cohort, the CLSA recruited and collected information from community dwelling males and females ages 45 to 85 years. Details about the CLSA's sampling and design have been published elsewhere (269). Ethics approval for the present analysis was not required by the McGill University Health Centre Research Ethics Board since the database is anonymized. We focused on the comprehensive cohort (n=30,097; face-to-face interviews at baseline and computer-assisted phone interview at 18 months), excluding those with any mood disorder in the last year, current anti-depressant use, and/or missing information on the outcomes and main exposure of interest as defined below (Figure 1).

Figure 2. Diagram flow chart for sample selection from the Canadian Longitudinal Study on Aging (CLSA)




CES-D= Center for Epidemiological Studies Depression 10 scale

Our primary outcome was UD defined by a Center for Epidemiological Studies Depression (CES-D) score ≥ 10. The short form of CES-D is a 10-item questionnaire with four possible choices for each question: all of the time, occasionally, some of the time, and rarely or never (214). The CES-D was found to be reliable and valid to assess symptoms of depression with a cut-off score of 10 in healthy community dwelling older adults (214, 219, 311, 312). Our secondary outcomes assessed at 18 months were 1) DS measured by the Kessler Psychological Distress Scale 10 (K10) score ≥ 19 (216), and 2) seeking MHCP consultation for these symptoms in the prior month. K10 is a 10-item questionnaire about distress feelings with each question scored from 1 to 5 (216). Individuals with a K10 ≥ 19 were considered by several studies to be likely experiencing subclinical symptoms of depression that required medical attention to prevent worsening (220-224). Hence, a K10 ≥ 19 was used as a proxy for having DS. Measures of CES-D and K10 were the only depression-related measures assessed at baseline and 18 months, respectively.

Baseline characteristics were grouped into: predisposing characteristics, enabling resources, needs-related factors (health status) and personal health habits as suggested by Andersen's behavioral model (273, 301). Predisposing characteristics included sex, age (45-60, 61-70 and 71-85 years), immigration status (yes/no), age at immigration, time lived in Canada, marital status (widowed, divorced or separated), cultural and racial background (White, Black,

South Asian, Chinese and Other) and language most spoken at home (French, English and other). Enabling resources were household income (Can$, < 20,000; 20,000-50,000; 50,000-100,000 and > 100,000), employment status (employed, unemployed and completely or partly retired), education (post-secondary, secondary, < secondary), province of residence (Ontario, British Columbia, Quebec, and other), and region of residence (urban or rural/suburban) (313). Needs-related factors included living with pain and history of common comorbid conditions such as cancer, arthritis, bowel disorders (Crohn's disease, ulcerative colitis or irritable bowel syndrome), myocardial infarction, diabetes, hypertension and, anxiety disorders (phobia, obsessive-compulsive disorders and panic disorders). Perceived health was reported in five categories "poor", "fair", "good", "very good" or "excellent". Personal health choices included alcohol consumption (no, occasional or regular) in the past year; participation in social activities involving sports or physical exercise in the past year (once a day, once a week, once a month, and once a year or never); smoking status (current, former and never); and body mass index (WHO classification for adults aged ≥ 18 years) (314).

## Statistical Analysis

Descriptive statistics with means and standard deviations (SD) for continuous variables and counts with percentages for categorical variables were computed by immigration status. Multivariate logistic regression models were used 1) to assess the associations between immigrant status and UD; 2) to examine the association between immigrant status and DS at 18 months in those depressed and those not depressed at baseline; and 3) to examine the association between immigrant status and consulting a MHCP at 18 months among those with and without DS at this time point. Immigration status, sex, age and province were included in all models, and all models adjusted for predisposing, enabling, needs-related and health-choice factors. In the model assessing the association between immigration status and UD, we examined the interaction effect between immigration status and other predisposing, enabling and needs factors. In the model assessing the association between immigration status and DS at 18 months, we examined the interaction effect between immigration status and UD at baseline and between UD at baseline and other predisposing, enabling and needs factors. Finally, in the model assessing the association between immigration status and MHCP at 18 months, we examined the interaction effect between

immigration status and DS and between DS and UD at baseline. A significance level of 0.05 and the Bayesian information criterion (BIC) were used to select the final models. To make the estimates generalizable to the Canadian population and address the complexity of the CLSA survey design, we used sample weights and geographic strata information provided by the CLSA in the descriptive analyses and regression analyses (315). Results were expressed in odds ratios (OR) and 95% confidence intervals (CI). The proportion of missing data was less than 5% for all variables considered except for income where it was 6.9%. Therefore, only complete data were analysed, and multiple imputations were not used. Statistical analyses were performed using SAS software package Version 9.4 (SAS Institute Inc., Cary, North Carolina, USA).

## Results

Our analyses included 23,002 individuals (Supplemental Figure 1). These were mostly from urban settings (87.7%; Table 1), White (95.2%), and primarily spoke English at home (81.9%). About half were men (53.0%) and most were married (71.6%). Their mean age was 63 years (SD 10.4 years) and over 75% had a household income above Can $50,000. Roughly, 85% had a post-secondary degree, over half were retired (55.9%) and 40.6% were employed. Most (65.7%) reported very good/excellent health. Hypertension (36.0%), diabetes (16.3%) and cancer (15.5%) were their most prevalent chronic diseases. One third (32.8%) lived with pain and 7.8% had bowel disorders. Almost half consumed alcohol more than twice a week, 7.5% were current smokers, 68.6% were obese or overweight and almost half participated in a social activity involving sports or a physical exercise with others at least once a week (48.1%) (Table 1).

Table 1. Baseline characteristics associated with immigrant status: multivariate logistic regression models

| | All respondents | Non-immigrant | Immigrant | Immigrant versus non-immigrant |
|---|---|---|---|---|
| | (N= 23,002) | (N= 18,620) | (N= 4,382) | (N= 22,278) |
| **Predisposing characteristics** | N (%) | N (%) | | Adjusted OR (95% CI)* |
| Age, years, mean (SD) | 63 (10.4) | 63 (10.3) | 65 (10.7) | - |
| 45 - 60 | 9,866 (42.9) | 8,355 (44.9) | 1,511 (34.5) | 1 |
| 61 - 70 | 6,905 (30.0) | 5,496 (29.5) | 1,409 (32.2) | 1.72 (1.53 - 1.93) |
| 71 - 85 | 6,231 (27.1) | 4,769 (25.6) | 1,462 (33.4) | 2.24 (1.96 - 2.57) |
| Sex | | | | |
| Male | 12,200 (53.0) | 9,699 (52.1) | 2,501 (57.1) | 1 |
| Female | 10,802 (47.0) | 8,921 (47.9) | 1,881 (42.9) | 0.82 (0.75 - 0.90) |
| Marital status | | | | |
| Single | 1,808 (7.9) | 1,575 (8.5) | 233 (5.3) | 1 |
| Married | 16,476 (71.6) | 13,221 (71.0) | 3,255 (74.3) | 1.79 (1.46 - 2.19) |
| Widowed/divorced/separated | 4,714 (20.5) | 3,821(20.5) | 893 (20.4) | 1.38 (1.12 - 1.69) |
| Cultural and racial background [a] | | | | |
| White | 21,888 (95.2) | 18,388 (98.8) | 3,500 (79.9) | - |
| Black | 199 (0.9) | 32 (0.2) | 167 (3.8) | - |
| South Asian | 255 (1.1) | 8 (0.0) | 247 (5.6) | - |
| Chinese | 196 (0.9) | 54 (0.3) | 142 (3.2) | - |
| Other | 399 (1.7) | 75 (0.4) | 324 (7.4) | - |
| Language most spoken at home | | | | |
| French | 4,121 (18.1) | 3,830 (20.6) | 291 (6.6) | 1 |
| English | 18,675 (81.9) | 14,768 (79.3) | 3,907 (89.2) | 6.27 (4.88 - 8.05) |
| Length of residence in Canada (years) | | | | |
| 0-5 | - | - | 57 (1.3) | - |
| 6-10 | - | - | 155 (3.5) | - |
| 11-20 | - | - | 336 (7.7) | - |
| 21-40 | - | - | 1,075 (24.5) | - |
| < 40 | - | - | 2,759 (63.0) | - |
| Age at arrival in Canada (years) | | | | |
| 0-5 | - | - | 733 (16.7) | - |
| 6-17 | - | - | 754 (17.2) | - |
| 18-22 | - | - | 618 (14.1) | - |

| | | | | |
|---|---|---|---|---|
| 22-40 | - | - | 1,869 (42.6) | - |
| < 40 | - | - | 408 (9.3) | - |
| **Enabling resources** | | | | |
| Total household income Can $ | | | | |
| < 20,000 | 894 (4.2) | 865 (4.3) | 169 (3.9) | 1 |
| 20,000- less than 50,000 | 4,546 (21.2) | 4,023 (19.8) | 943 (21.5) | 0.80 (0.63 - 1.02) |
| 50,000- less than 100,000 | 7,657 (35.6) | 6,733 (33.1) | 1,479 (33.8) | 0.60 (0.47 - 0.77) |
| ≥ 100,000 | 8,395 (39.0) | 7,434 (36.6) | 1,452 (33.1) | 0.48 (0.37 - 0.62) |
| Working status | | | | |
| Employed | 9,317 (40.6) | 7,622 (40.9) | 1,695 (38.7) | 1 |
| Unemployed | 809 (3.5) | 637 (3.4) | 172 (3.9) | 1.27 (1.01 - 1.61) |
| Retired | 12,815 (55.9) | 10,311 (55.4) | 2,504 (57.1) | 0.64 (0.57 - 0.72) |
| Education level | | | | |
| < Secondary school | 1,204 (5.2) | 1,071 (5.8) | 133 (3.0) | 1 |
| Secondary school | 2,171 (9.5) | 1,851 (9.9) | 320 (7.3) | 1.62 (1.24 - 2.14) |
| Post-secondary degree/diploma | 19,589 (85.3) | 15,680 (84.2) | 3,909 (89.2) | 2.46 (1.93 - 3.12) |
| Setting | | | | |
| Urban | 19,918 (87.7) | 16,007 (86.0) | 3,911 (89.3) | 1 |
| Rural/suburban | 2,795 (12.3) | 2,385 (12.8) | 410 (9.4) | 0.77 (0.67 - 0.88) |
| Province | | | | |
| Quebec | 4,384 (19.1) | 3,856 (20.7) | 528 (11.0) | 1 |
| British Columbia | 4,734 (20.6) | 3,409 (18.3) | 1,325 (30.2) | 0.66 (0.53 - 0.83) |
| Ontario | 4,867 (21.1) | 3,713 (19.9) | 1,154 (26.3) | 0.60 (0.48 - 0.74) |
| Other | 9,017 (39.2) | 7,642 (41.0) | 1,375 (31.4) | 0.31 (0.25 - 0.39) |
| **Needs-related factors** | | | | |
| Perceived Health | | | | |
| Poor | 190 (0.8) | 140 (0.8) | 50 (1.1) | - |
| Fair | 1,324 (5.8) | 1,072 (5.8) | 252 (5.8) | - |
| Good | 6,364 (27.7) | 5,068 (27.2) | 1,296 (29.6) | - |
| Very Good | 9,966 (43.3) | 8,189 (44.0) | 1,777 (40.6) | - |
| Excellent | 5,141 (22.4) | 4,139 (22.2) | 1,002 (22.9) | - |
| Medical Conditions (Yes vs. No) | | | | |
| Living with pain | 7,232 (32.8) | 5,846 (31.4) | 1,386 (31.6) | - |
| Bowel disorders | 1,798 (7.8) | 1,500 (8.1) | 298 (6.8) | 0.78 (0.66 - 0.92) |
| Arthritis | 655 (2.9) | 524 (2.8) | 131 (3.0) | - |
| Myocardial infarction | 1,087 (4.7) | 867 (4.7) | 220 (5.0) | - |

| | | | | |
|---|---|---|---|---|
| Stroke | 351 (1.5) | 274 (1.5) | 77 (1.8) | - |
| Cancer | 3,551 (15.5) | 2,856 (15.3) | 695 (15.9) | 0.86 (0.77 - 0.97) |
| Hypertension | 8,250 (36.0) | 6,632 (35.6) | 1,618 (36.9) | - |
| Diabetes | 3,738 (16.3) | 2,997 (16.1) | 741 (16.9) | - |
| Anxiety disorders | 715 (3.1) | 611 (3.3) | 104 (2.4) | - |
| **Personal health choices** | | | | |
| Alcohol consumption | | | | |
| Never | 2,331 (10.4) | 1,845 (9.9) | 486 (11.1) | - |
| About once a month | 4,095 (18.2) | 3,281 (17.6) | 814 (18.6) | - |
| 2-4 times a month | 4,865 (21.7) | 4,049 (21.7) | 816 (18.6) | - |
| > 2 times a week | 11,155 (49.7) | 9,063 (48.7) | 2,092 (47.7) | - |
| Smoking status | | | | |
| Smoker | 1,704 (7.5) | 1,470 (7.9) | 234 (5.3) | 1 |
| Former smoker | 13,697 (59.9) | 11,248 (60.4) | 2,449 (55.9) | 1.38 (1.13 - 1.68) |
| Non-smoker | 7,470 (32.7) | 5,795 (31.1) | 1,675 (38.2) | 1.72 (1.41 - 2.11) |
| Weight classification [b] | | | | |
| Underweight | 157 (0.7) | 124 (0.7) | 33 (0.8) | 0.93 (0.55 - 1.50) |
| Normal weight | 7,039 (30.7) | 5,586 (30.0) | 1,453 (33.2) | 1 |
| Overweight | 9,465 (41.3) | 7,630 (41.0) | 1,835 (41.9) | 0.88 (0.80 - 0.97) |
| Obese | 6,261 (27.3) | 5,209 (28.0) | 1,052 (24.0) | 0.73 (0.65 - 0.82) |
| Physical activity | | | | |
| Never or once a year | 5,570 (24.3) | 4,350 (23.4) | 1,220 (27.8) | 1 |
| Once a month | 4,147 (18.0) | 3,421 (18.4) | 726 (16.6) | 0.77 (0.68 - 0.88) |
| Once a week | 11,046 (48.1) | 9,012 (48.4) | 2,034 (46.4) | 0.75 (0.67 - 0.83) |
| Once a day | 2,207 (9.6) | 1,810 (9.7) | 397 (9.1) | 0.70 (0.59 - 0.82) |

OR= Odds Ratio, CI= Confidence Interval;

The variables that were not significant (p-value > 0.05) on the multivariate level were removed from the table. Sex, age and province were forced in the model.

[a] Cultural and racial background variable was excluded from the univariate and multivariate logistic regression because it was highly correlated with immigrant status.

[b] Based on Body Mass Index international classification for adults ≥ 18 years of age.

Nearly one fifth (19.1%) of our study individuals had immigrated to Canada, the majority > 20 years ago (87.5%) and only 1.3% had lived in Canada for < 5 years. In multivariate logistic regression models, immigrants (versus non-immigrants) were more likely male, older, with post-secondary degree/diploma, to speak English most often at home (versus French), unemployed (versus employed), with lower incomes, residing in Quebec (versus other). Immigrants were less likely single, smokers, living in rural/suburban areas, with bowel disorders or cancer, and less likely overweight or obese (Table 1).

Among immigrants, 12.2% had UD at baseline compared to 10.6% of non-immigrants (Table 2). Risk factors associated with UD at baseline did not differ greatly between immigrants and non-immigrants (Supplemental Table A). Non-immigrant (but not immigrants) who were unemployed (versus employed) or had prior anxiety disorders were at higher risk of UD, while those who exercised at least once a week were at lower risk. Immigrants (but not non-immigrants) who consumed alcohol once a month (versus never) and those who were current smokers were at higher risk of UD.

In the multivariate logistic regression model evaluating the association between immigrant status and UD, an effect modification of immigrant status by sex was observed. Specifically, among males, immigrant status was not associated with UD (OR 1.05, 95% CI: 0.86-1.28), but among females, immigrant status was associated with a 50% increased odd of UD (OR 1.50, 95% CI: 1.25-1.80) (Table 3).

Table 2. Crude prevalence of mental health outcomes by immigration status

| Non-immigrants (N= 18,620) | | | | Immigrants (N= 4,382) | | | |
|---|---|---|---|---|---|---|---|
| **At baseline** *Response to CES-D, N (%)* | | | | | | | |
| UD | | No-UD | | UD | | No-UD | |
| 1,976 (10.6) | | 16,644 (89.04) | | 535 (12.2) | | 3,847 (87.8) | |
| **At 18 months** *Response to K10[a], N (%)* | | | | | | | |
| ≥ 19 | < 19 | ≥ 19 | < 19 | ≥ 19 | < 19 | ≥ 19 | <1 9 |
| 621 (31.4) | 1,355 (68.6) | 1,005 (6.0) | 15,639 (94.0) | 181 (39.2) | 281 (60.8) | 231 (8.8) | 2,407 (91.2) |
| *Number of respondents to MHCP [b]* | | | | | | | |
| 620 | 1,115 | 1,003 | 11,142 | 181 | 281 | 231 | 2,407 |
| *Seen a MHCP, N (%)* | | | | | | | |
| 93 (15.0) | 75 (6.7) | 147 (14.7) | 419 (3.8) | 31 (17.1) | 11 (3.9) | 44 (19.1) | 82 (3.4) |

CES-D: Center for Epidemiological Studies Depression 10 Scale
UD: undiagnosed depression; assessed with Center for Epidemiological Studies Depression 10 Scale, CES-D ≥ 10
K10: Kessler Psychological Distress Scale 10
MHCP: consulting a mental health care professional for depressive symptoms;
[a]K10 ≥ 19 = Depressive symptoms
[b]Participants who answered"a little", "some", "most" or "all" to at least one question in the K10 series were probed about having seen a MHCP about these feelings in the prior 30 days

Table 3. Effect of immigrant status and sex on undiagnosed depression at baseline [a]

| | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|
| Female immigrant versus female non-immigrant | 1.46 (1.28 - 1.75) | 1.50 (1.25 - 1.80) |
| Female immigrant versus male immigrant | 2.00 (1.62 - 2.47) | 1.85 (1.45 - 2.37) |
| Female non-immigrant versus male non-immigrant | 1.39 (1.25 - 1.55) | 1.30 (1.14 - 1.47) |
| Male immigrant versus male non-immigrant | 1.04 (0.87 - 1.25) | 1.05 (0.86 - 1.28) |

UD= Undiagnosed Depression; OR=Odds Ratio; CI=Confidence Interval;
[a] An interaction effect of sex and immigrant was found and is presented here. The multivariate logistic regression models (N=23,002) adjusted for all baseline characteristics included in Table 1. The full model is shown in the supplemental material.

Female immigrant and female non-immigrant were more likely to be depressed than their male counterparts (immigrant females vs. immigrant males [OR 1.85, 95% CI: 1.45-2.37] and non-immigrant females vs. non-immigrant males [OR 1.30, 95% CI: 1.14-1.47]) (full model in supplemental Table B). Immigrants who arrived in Canada at age >40 years were twice as likely as non-immigrants to have UD (OR 2.02, 95% CI: 1.43-2.86). As well, those who resided in Canada for < 20 years or > 40 years were more likely than non-immigrants to have UD (Supplemental Table C).

Among immigrants with UD at baseline, 34.2% had DS at 18 months, among whom 17.1% had consulted a MHCP in the previous month, while among non-immigrants with UD at baseline, 31.4% had DS at 18 months, among whom 15.0% had consulted a MHCP in the previous month (Table 2). In multivariate logistic regression models, the risk of DS at 18 months was not statistically different between immigrants and non-immigrants whether or not they had UD at baseline (Table 4). An interaction effect was found between sex and UD at baseline whereby UD increased the risk of DS at 18 months for females (females with UD versus females without UD: OR 5.10, 95% CI: 4.29-6.06) and for males (males with UD versus males without UD: OR 6.02, 95% CI: 4.90-7.41), and the risk of UD was higher in females without UD versus males without UD, but similar in females with UD versus males with UD (Table 4). The results of the full model are displayed in the supplemental Table D.

In multivariate regression models, the overall likelihood of consulting a MHCP at 18 months did not differ between immigrants and non-immigrants (OR 0.95, 95% CI: 0.77-1.17) whether or not they had DS. Examining the interaction effect of DS at 18 months and UD at baseline revealed that the likelihood of consulting a MHCP among those with DS did not differ between those with and those without UD at baseline (Table 5). Interestingly, those with UD at baseline and no DS (K10 < 19) were 58% more likely to consult a MHCP than those without UD at baseline. The full model is displayed in supplemental Table E.

Table 4. Associations of immigrant status with and without UD at baseline with DS at 18 months (N=23,002) [a]

| | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
|---|---|---|
| *Interaction effect of immigrant status and UD at baseline* | | |
| Immigrant with UD versus immigrant without UD | 7.41 (5.73 - 9.57) | 5.37 (4.04 - 7.14) |
| Immigrant with UD versus non-immigrant with UD | 1.08 (0.86 - 1.37) | 1.10 (0.84 - 1.45) |
| Immigrant without UD versus non-immigrant without UD | 1.11 (0.94 - 1.31) | 1.15 (0.95 - 1.39) |
| Non-immigrant with UD versus non-immigrant without UD | 7.56 (6.64 - 9.62) | 5.59 (4.79 - 6.52) |
| *Interaction effect of sex and UD at baseline* [b] | | |
| Female with UD versus female without UD | 6.71 (5.75 - 7.81) | 5.10 (4.29 - 6.06) |
| Female with UD versus male with UD | 0.95 (0.78 - 1.15) | 1.06 (0.84 - 1.33) |
| Female without UD versus male without UD | 1.21 (1.06 - 1.37) | 1.25 (1.09 - 1.44) |
| Male with UD versus male without UD | 8.47 (7.14 - 10.20) | 6.02 (4.90 - 7.41) |

OR= Odds Ratio; CI= Confidence Interval; UD= Undiagnosed Depression; DS= Depressive Symptoms. [a] The multivariate logistic regression model adjusted for all the variables included in Table 1. The full model is in the supplemental material. [b] The model did not show a three-way interaction of immigrant status, sex and UD at baseline

Table 5. Associations of immigrant status, baseline UD and DS at 18 months with seeing a MHCP [a]

| | Seeing a mental health care professional at 18 months | |
|---|---|---|
| | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
| Immigrant versus non-immigrant | 1.02 (0.83 - 1.23) | 0.95 (0.77 - 1.17) |
| *Interaction effect of DS at 18 months and UD at baseline* | | |
| DS with UD versus no DS with UD | 3.01 (2.16 - 4.18) | 3.11 (2.20 - 4.37) |
| DS with no UD versus no DS with no UD | 4.88 (3.99 - 5.97) | 5.05 (4.09 - 6.24) |
| DS with UD versus DS with no UD | 0.93 (0.70 - 1.23) | 0.97 (0.72 - 1.30) |
| No DS with UD versus no DS with no UD | 1.75 (1.34 - 2.28) | 1.58 (1.19 - 2.09) |

CES-D= Center for Epidemiological Studies Depression 10 Scale; K10= Kessler Psychological Distress Scale 10; UD= Undiagnosed Depression, defined by CES-D score ≥ 10 at baseline; DS= Depressive Symptoms, defined by K10 score ≥ 19 at 18 months; MHCP= Mental Health Care Professional OR= Odds Ratio; CI= Confidence Interval;
[a] Multivariate logistic regression models (N= 16,519) were conducted and the full table can be found in the supplemental material.

## Discussion

Among 23,002 study participants, one fifth had immigrated to Canada, and the majority (86%) was over 20 years ago. Female immigrants were more likely to have UD than female non-immigrants, but no difference was observed in men. The risk of UD was higher in immigrants who arrived in Canada at age > 40 years and among those who resided in Canada for < 20 years or > 40 years. Persistent DS at 18 months and seeking MHCP for these symptoms did not differ between immigrants and non-immigrants. Of note, only 17% of immigrants and 15% of non-immigrants with persistent DS (DS at 18 months and baseline UD) had consulted a MHCP in the previous month.

As expected, immigrants in our study differed from non-immigrants on all mental health-predisposing, enabling, needs-related and personal health choices considered except for perceived health and alcohol consumption. Similar to other studies, immigrants were more likely to have post-secondary education and lower income (44, 69, 316). However, they were less likely to be obese and to be living with pain or cancer (22, 31, 43, 140, 230, 317). Immigrants are reported to be resilient because of their experiences, and hence, probably moderating pain levels (193). In terms of cancer and obesity, being an immigrant was seen to be protective in our study. Similar findings were also reported in other Canadian studies among recent immigrants, but over time, the benefits seem to diminish to Canadian norms (230, 318).

The risk of UD has not been previously assessed in Canadian immigrants. In a US study, UD was associated with psychosocial stressors including unemployment and relationship problems, but immigration status was not specifically examined (319). The higher risk of UD found in female immigrants versus non-immigrants is in line with results of other studies that looked at the risk of depression in these groups (296, 298, 320-322). The higher exposure to stressors such as post-partum depression, family separation and linguistic, and economic barriers in female immigrants may explain this result (279, 295, 298, 320-323). Women are also at higher risk of inflammation and fluctuation of reproductive hormones that make them further susceptible to depression (324). In our study, the risk of UD was similar between male immigrants and non-immigrants. Other Canadian studies also found no association between male sex and depression regardless of immigration status (35, 76).

In our study, immigrants who resided in Canada for < 20 years and those who resided for > 40 years were at increased risk of UD than the host population. Our findings support a "U" shape association between UD and length of stay in the host country (11). Immigrants go through several acculturation and integration challenges in their host country during the first 20 years following their migration that might make them vulnerable to anxiety and mood disorders (122, 143, 325, 326). These stressors can include economic challenges reflecting aspects of acceptance by the receiving society, communication barriers, discrimination, loneliness and family structure, lack of social support, and cultural adaptation (305, 327, 328). Migrants' cultural shaping of symptoms, illness behaviour, and coping can delay seeking help (24) as well as structural healthcare challenges that accommodate "cultural distance" and health inequalities (329) can delay seeking help. During the following 20-40 years of residence, immigrants then adapt their culturally-defined lifestyles and adopt the norms and behaviors of the host country (11). However, when residing > 40 years in the host country, deterioration in social determinants of health (living alone, lower levels of physical health status, financial status, impaired social integration, and social activity) may arise and could explain mood dysfunction at that stage (330).

Our results also showed an increased risk of UD in those who migrated at ages > 40 years. Contrary to our results, one US study reported a lower risk of psychiatric disorders onset in US Latino groups with older ages at arrival (162, 331). However, other studies reported that Latino immigrants are at higher risk of psychiatric disorders when immigrating during two life cycle periods: before the age of 16 (332) or after the age of 35 (333). Most US studies were conducted in Latino groups which differ from our Canadian cohort who are mostly of South Asian, Black and Chinese backgrounds. Mood disorders and seeking mental health care may differ between ethnic groups, however having a strong community structure of collectivism like in Latino communities might help navigate the healthcare system, and hence, have a positive impact on psychiatric disorders (22, 31, 43, 140, 230, 317). The intricate relationship between UD, age at immigration, and residency length requires further clarification (15).

In our study, immigrants were as likely as non-immigrants to have persistent DS at 18 months and to have consulted a MHCP for these symptoms in the past month. These results differ from those reported by other Canadian studies that found immigrants to be less likely than their Canadian-born counterparts to seek out or be referred to mental health services when they experience comparable levels of distress (23, 86, 293). The length of residency (~43 years) in our

study may be a possible explanation of the permeability (how easily people can use services) and identification (how need is identified in specific situations) of immigrants in accessing mental health services (303). Immigrants and non-immigrants who had UD at baseline were 5-times as likely as their counterparts without UD to have DS at 18 months. This highlights the importance of screening and treating depression early to limit the risk of persistent depressive disorders. No other study was found that assessed the likelihood of seeking mental health care among immigrant and non-immigrant with persistent DS.

Strengths of our study include the use of the carefully designed, population-based CLSA database and the high quality of its data. Our study has also some limitations. Although we used the survey weights in our analyses, participation bias cannot be ruled out (334). Our study included only community dwelling individuals. As such, vulnerable groups that are particularly at higher risk of depression would be excluded (e.g. homeless, those living in institutions). In addition, the screening tools CES-D at baseline and K10 at 18 months were the only depression-related measures available in the CLSA data at the time of the study. Both CES-D (335) and K10 (336) are reliable and valid instrument to assess depressive symptoms in the general population. Therefore, we anticipate no changes in our results had the same measurement been available at both time-point. However, CES-D and K10 are based on self-reported information that come with measuring errors and information bias (337). Finally, in our study, only information on seeing a MHCP in the past month for their feelings was available.

Future studies should further investigate the personal, cultural and social factors (303) that differentiates newer immigrants (those who reside < 20 years) from those who have been in their host country for over 40 years and from the host population as these factors continue to evolve over time with new global challenges and societal structures. It is important to continue assessing the implications of help-seeking factors, cross-cultural differences, social inequalities, and other psychological measures over time in large population-based cohorts as with the continued societal changes, cultural barriers and differences of cultural significance of somatic symptoms might need further exploration (24, 338). Conducting qualitative work may help gain important insights into our quantitative findings (24).

To the best of our knowledge, this is the first Canadian study to comprehensively assess associations between UD and immigration status. Screening for depression may particularly

benefit female immigrants and those who migrated at 40 years of age and older. Systematic inquiry into patients' migration trajectory and subsequent follow-up on culturally appropriate indicators of health will allow clinicians to recognize problems in adaptation and undertake mental health promotion, disease prevention or treatment interventions in a timely way. Follow-up screening should query persistence of DS and encourage seeking mental health care regardless of immigration status.

## Chapter V: Depression, diabetes and immigration status: a retrospective cohort study using the Canadian Longitudinal Study on Aging

### Preamble of Manuscript 2

In my first manuscript, I investigated differences between immigrants and non-immigrants in the risk and predictors of undiagnosed depression, risk and predictors of persistent depressive symptoms, likelihood of seeking mental health care for depressive symptoms and the facilitators and barriers to mental health care seeking.

I found an increased risk of undiagnosed depression in immigrants vs non-immigrants. This increase in risk was present in female, but not in male immigrants. I also found a higher risk of undiagnosed depression among immigrants who were over 40 years of age at arrival in Canada and among those whose time of residence in Canada was less than 20 years or over 40 years, as compared to non-immigrants. This suggested that the risk ratio of undiagnosed depression in immigrants compared to non-immigrants varied by time of residence and its variation was not linear, but perhaps followed a "U" shape. As reviewed previously, immigrants face acculturative stressors that may be more pronounced at the start of their immigration journey with some of these stressors partially fading and others emerging over time (339, 340). Immigrants in my study experienced a decline in the risk of depression after 20 years of residence, but the risk tended to pick up again and increase beyond that of the general population after 40 years of residence. When examining the risk of persistent depressive symptoms at 18 months and seeking mental health care for these symptoms at this time-point, I did not observe differences between immigrants and non-immigrants.

Building on the knowledge gained from my first study regarding differences between immigrants and non-immigrants in the risk of depression and its predisposing and enabling factors, I examined the role of having a chronic disease on that risk in immigrants and non-immigrants in my second manuscript. In particular, I investigated the role of diabetes status as a risk factor for developing depression over a 3-year time period in immigrants and non-immigrants. I also investigated the role of depression status as a risk factor for developing diabetes over the same time-period. This

circular relationship is important to evaluate because it is likely to increase the burden of these comorbidities beyond the sum of each one alone.

Canadian studies have reported a higher risk of diabetes in immigrants, particularly those originating from South Asia, the Caribbean, sub-Saharan Africa and Latin America compared to non-immigrants or to immigrants originating from other regions such as Europe and North America. The reasons for this higher risk were thought to be related to genetic susceptibility, acculturative stress level, and transition to unhealthy lifestyle choices such as unhealthy diets and sedentary lifestyle. Having a chronic disease such as diabetes adds the challenges related to accessing and adhering to medical care to the acculturative stress in immigrants and may increase their risk of depression over and beyond that of their non-immigrant peers. Diabetes status has not been previously studied as a risk factor for depression in immigrants.

Previous studies have also found depression and depressive symptoms to increase the risk of diabetes in the general population (239, 240). The higher risk of depression compounded with the transition to unhealthy lifestyle habits in immigrants may increase their risk of diabetes beyond that seen in the general population. Depression status has not been previously studied as a risk factor for developing diabetes in immigrants.

In summary, in my second manuscript, I conducted two separate analyses to examine the role of depression as a risk factor for developing diabetes over a 3-year period, and the role of diabetes as a risk factor for developing depression over a 3-year period in immigrants and non-immigrants. My second study was published in the *Canadian Medical Association Journal Open* on June 16, 2022.

Farid D, Li P, Da Costa D, Afif W, Szabo J, Dasgupta K and Rahme E. Depression, diabetes and immigration status: a retrospective cohort study using the Canadian Longitudinal Study on Aging. *CMAJ Open*. 2021;29:e158.

**Depression, diabetes and immigration status: a retrospective cohort study using the Canadian Longitudinal Study on Aging**


## Abstract

**Background:** A bidirectional association between depression and diabetes exists, but has not been evaluated in the context of immigrant status. Given that social determinants of health differ between immigrants and nonimmigrants, we evaluated the association between diabetes and depression incidence, depression and diabetes incidence, and whether immigrant status modified this association, among immigrants and nonimmigrants in Canada.

**Methods:** We employed a retrospective cohort design using data from the Canadian Longitudinal Study on Aging Comprehensive cohort (baseline [2012–2015] and 3-year follow-up [2015–2018]). We defined participants as having diabetes if they self-reported it or if their glycated hemoglobin $A_{1c}$ level was 7% or more; we defined participants as having depression if their Center for Epidemiological Studies Depression score was 10 or higher or if they were currently undergoing depression treatment. We excluded those with baseline depression (Cohort 1) and baseline diabetes (Cohort 2) to evaluate the associations between diabetes and depression incidence, and between depression and diabetes incidence, respectively. We constructed logistic regression models with interaction by immigrant status.

**Results:** Cohort 1 (*n* = 20 723; mean age 62.7 yr, standard deviation [SD] 10.1 yr; 47.6% female) included 3766 (18.2%) immigrants. Among immigrants, 16.4% had diabetes, compared with 15.6% among nonimmigrants. Diabetes was associated with an increased risk of depression in nonimmigrants (adjusted odds ratio [OR] 1.27, 95% confidence interval [CI] 1.08–1.49), but not in immigrants (adjusted OR 1.12, 95% CI 0.80–1.56). Younger age, female sex, weight change, poor sleep quality and pain increased depression risk. Cohort 2 (*n* = 22 054; mean age 62.1 yr, SD 10.1 yr; 52.2% female) included 3913 (17.7%) immigrants. Depression was associated with an increased risk of diabetes in both nonimmigrants (adjusted OR 1.39, 95% CI 1.16–1.68) and immigrants (adjusted OR 1.60, 95% CI 1.08–2.37). Younger age, male sex, waist circumference, weight change, hypertension and heart disease increased diabetes risk.

**Interpretation:** We found an overall bidirectional association between diabetes and depression that was not significantly modified by immigrant status. Screening for diabetes for people with depression and screening for depression for those with diabetes should be considered.

## Background

Screening for diabetes and depression is recommended in recently arrived immigrants (83). In addition, given some evidence for a bidirectional association between diabetes and depression in the general population (91-94), ongoing surveillance for diabetes may be relevant in the context of depression and, likewise, ongoing surveillance for depression may be justified with people with diabetes, particularly among immigrants.

Immigrants may be particularly vulnerable to the development of diabetes and depression (74, 75, 341, 342) owing to factors associated with resettlement, such as acculturation, stress and social and economic challenges (76, 94, 197, 303, 343-347). For example, studies have reported that immigrants from South Asian countries are generally healthy upon arrival but rapidly develop diabetes after immigration (71, 85). Studies have also reported that immigrants with diabetes are at higher risk of depression than the general host population (74, 75) and the population in their country of origin (11, 76-81). Conversely, immigrants with depression may also be at high risk of diabetes because of complex social determinants of health (82-85) and delayed diagnosis of and treatment for diabetes (23, 24, 86-88); use of antidepressants may also increase diabetes risk (348, 349).

To explore the bidirectional association between diabetes and depression in the context of immigrant status, we evaluated the association between diabetes and depression incidence, the association between depression and diabetes incidence, and whether immigration status modified this association, among immigrants and nonimmigrants in Canada.

## Methods

### *Study design*

We used a retrospective cohort design to evaluate the association between diabetes and depression incidence (Cohort 1) and the association between depression and diabetes incidence (Cohort 2). We used data from the Canadian Longitudinal Study on Aging (CLSA) Comprehensive cohort at baseline (2012–2015) and 3-year follow-up (2015–2018) to construct our study cohorts (269, 270). The paper was reported according to the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) checklist (350).

*Data source and population*

The CLSA Comprehensive cohort included community-dwelling individuals, aged 45–85 years, who were randomly selected from within a 25-km radius of 11 sites in cities across Canada using the provincial health care registration databases and random digit dialing of landline telephones (269, 270). Participants provided demographic, social, physical, clinical, psychological and economic data at baseline and at 3-year follow-up through an in-person interview, on-site physical examinations and blood and urine collection. Details about the CLSA's sampling, design and data collection have been published (105, 272).

We defined participants as having diabetes if they self-reported a diagnosis with any type of diabetes (i.e., answered yes to "Has a doctor ever told you that you have diabetes, borderline diabetes or that your blood sugar is high?") or if their glycated hemoglobin ($HbA_{1c}$) level was 7% or more. We defined participants as having depression if their Center for Epidemiological Studies Depression-10 Scale (CES-D-10) score was 10 or higher or if they self-reported being currently treated for depression (214, 219, 311, 312).. For both Cohort 1 and Cohort 2, we excluded participants missing information on immigration, depression or diabetes at baseline. In addition, for Cohort 1, we excluded those with baseline depression and those with missing depression status in follow-up; for Cohort 2, we excluded those with baseline diabetes and those with missing diabetes status in follow-up. The CLSA defined immigrants using 2 questions: "In what country were you born?" and "In what year did you first come to Canada to live?" (351)

*Exposure and outcomes*

Our outcomes were depression incidence for Cohort 1 and diabetes incidence for Cohort 2, assessed using the 3-year follow-up data. Depression was defined the same at follow-up as at baseline, but diabetes in follow-up was based only on self-report because $HbA_{1c}$ data were unavailable at that time point. The main exposure variables were baseline diabetes for Cohort 1 and baseline depression for Cohort 2.

*Baseline characteristics*

The baseline characteristics for Cohort 1 and Cohort 2 included those previously associated with both diabetes and depression, namely self-reported predisposing sociodemographic and socioeconomic factors, medical conditions and lifestyle choices, as well as anthropomorphic measurements and blood assessments. The predisposing sociodemographic and socioeconomic factors included sex, age, ethnic or racial background, immigration status, time since migration, marital status, language most spoken at home, household income, employment status, education, province and place of residence. The place of residence classification (urban or rural) was derived by the CLSA based on Statistics Canada's Postal Code Conversion File, whereby rural areas were those with a total population of fewer than 10,000 people (352). The medical conditions included pain (353), cancer (354), arthritis (355), bowel disorders (356), and hypertension (357). The lifestyle choices included perceived health, sleep satisfaction, alcohol consumption, smoking status and nutritional risk. The anthropomorphic measurements and blood assessments included body mass index, waist circumference (358), weight change (359) and vitamin D deficiency (360, 361). Details on these baseline characteristics are provided in Appendix 1.

In addition, we assessed self-reported comorbidities associated with depression, including heart disease (362, 363), kidney disease (364) and iron deficiency (360, 361, 365), for Cohort 1; we considered participant lipid profiles (assessed from blood tests) (366) and lean and fat mass (measured with dual-energy x-ray absorptiometry) (367) for Cohort 2.

## Statistical analysis

For each cohort, we computed descriptive statistics with means and standard deviations (SDs) for continuous variables and counts with percentages for categorical variables, by immigration and baseline diabetes statuses (Cohort 1) or by immigration and baseline depression statuses (Cohort 2).

Among immigrants and nonimmigrants, we compared baseline characteristics by baseline diabetes status (Cohort 1) or by baseline depression status (Cohort 2) using multivariable logistic regression models. We used these models to evaluate the associations between baseline diabetes and the risk of depression at 3 years in Cohort 1 and between depression at baseline and the risk

of 3-year diabetes in Cohort 2. To assess the effect modification by immigration status, we included interaction terms for diabetes and immigration status and for depression and immigration status in the models for Cohort 1 and Cohort 2, respectively.

The baseline characteristics listed above were considered for inclusion in the multivariable model. Immigration status, sex and age were forced in all models. We removed other variables that were not significant ($p \geq 0.5$), did not affect the Bayesian Information Criterion upon inclusion and did not modify the effect of the main exposure variable by more than 10% (368, 369).To make the estimates generalizable to the Canadian population, we used the CLSA analytical sample weights and geographic strata information in the regression analyses (315, 370). Results were expressed in odds ratios (ORs) and 95% confidence intervals (CIs).

We also conducted sensitivity analyses. First, we defined baseline diabetes solely by the self-reported physician diagnosis and repeated the main analyses for Cohort 1. Second, we conducted the main analyses excluding individuals with missing variables. We repeated these analyses using multiple imputations to impute missing information using the Markov Chain Monte Carlo method, as implemented in SAS Proc MI (371). Five imputed data sets were generated based on all baseline characteristics. The results from these data sets were combined using Rubin's rules (372), as implemented by SAS Proc MIANALYZE. We performed all statistical analyses using SAS version 9.4 (SAS Institute).

### *Ethics approval*

Ethics approval was provided by the McGill University Health Centre Research Ethics Board.

## Results

### *Diabetes at baseline and risk of depression at 3 years*

Cohort 1 included 20,723 individuals (Figure 1), including 3766 (18.2%) immigrants. Among immigrants, 616 (16.4%) had diabetes at baseline, compared with 2,639 (15.6%) among nonimmigrants (Table 1). In general, baseline characteristics that differed between individuals with or without baseline diabetes were similar in immigrants and nonimmigrants (Appendix 1, Table 1).

Figure 1. Flow chart of study cohort

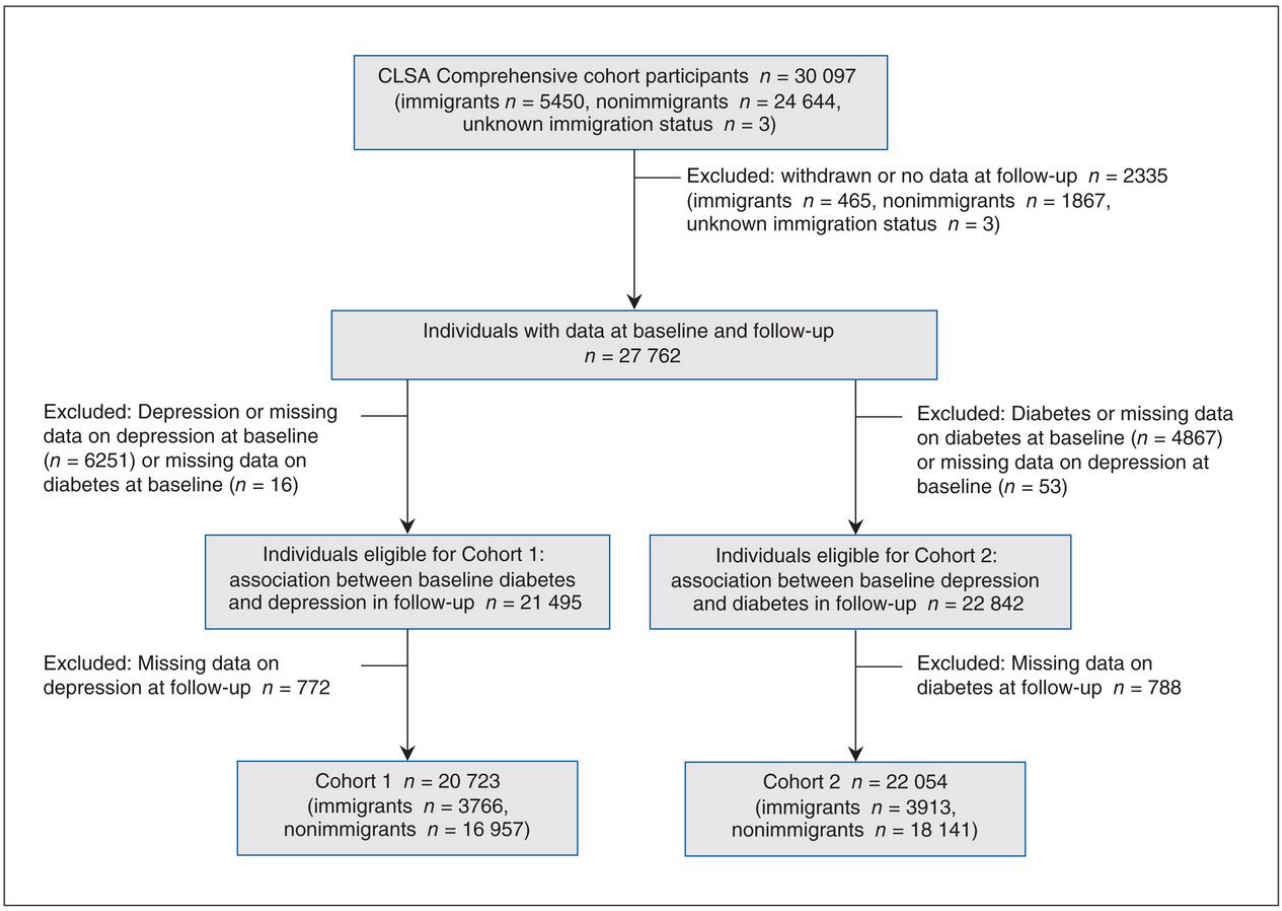


Table 1. Baseline characteristics of Cohort 1 individuals with and without baseline diabetes by immigration status

| | Immigrant (N= 3,766) | | Non-immigrant (N= 16,957) | |
|---|---|---|---|---|
| | Diabetes (N= 616) | No Diabetes (N= 3,150) | Diabetes (N= 2,639) | No Diabetes (N= 14,318) |
| | N (%) | | N (%) | |
| Age, years | | | | |
| 45-60 | 141 (22.9) | 1,173 (37.2) | 893 (33.8) | 7,050 (49.2) |
| 61-70 | 236 (38.3) | 1,050 (33.3) | 969 (36.7) | 4,224 (29.5) |
| 71-85 | 239 (38.8) | 927 (29.4) | 777 (29.4) | 3,044 (21.3) |
| Sex | | | | |
| Male | 408 (66.2) | 1,743 (55.3) | 1,551 (58.8) | 7,167 (50.1) |
| Female | 208 (33.8) | 1,407 (44.7) | 1,088 (41.2) | 7,151 (49.9) |
| Marital status | | | | |
| Single | 27 (4.4) | 149 (4.7) | 234 (8.9) | 1,176 (8.2) |
| Married | 455 (73.9) | 2,405 (76.3) | 1,834 (69.5) | 10,407 (72.7) |
| Widowed/divorced/separated | 134 (21.8) | 595 (18.9) | 571 (21.6) | 2,731 (19.1) |
| Language most spoken at home | | | | |
| French | 31 (5.0) | 205 (6.5) | 541 (20.5) | 3,171 (22.1) |
| English | 492 (79.9) | 2,597 (82.4) | 2,092 (79.3) | 11,114 (77.6) |
| Other | 55 (8.9) | 254 (8.1) | 3 (0.1) | 17 (0.1) |
| Ethnic/racial background | | | | |
| White | 464 (75.3) | 2,640 (83.8) | 2,596 (98.4) | 14,166 (98.9) |
| Black | 36 (5.8) | 89 (2.8) | 8 (0.3) | 19 (0.1) |
| South Asian | 50 (8.1) | 122 (3.9) | 0 (0.0) | 6 (0.0) |
| Chinese | 24 (3.9) | 107 (3.4) | 8 (0.3) | 37 (0.3) |
| Other | 42 (6.8) | 188 (6.0) | 25 (0.9) | 80 (0.6) |
| Years since arrival to Canada | | | | |
| < 20 | 42 (6.8) | 396 (12.6) | - | - |
| 20-40 | 162 (26.3) | 781 (24.8) | - | - |
| > 40 | 412 (66.9) | 1,973 (62.6) | - | - |
| Total household income (CAD $) | | | | |
| < 20,000 | 29 (4.7) | 82 (2.6) | 140 (5.3) | 432 (3.0) |

| | | | | |
|---|---|---|---|---|
| 20,000-50,000 | 141 (22.9) | 589 (18.7) | 641 (24.3) | 2,435 (17.0) |
| 50,000-100,000 | 245 (39.8) | 1,076 (34.2) | 927 (35.1) | 4,786 (33.4) |
| > 100,000 | 163 (26.5) | 1,180 (37.5) | 779 (29.5) | 5,855 (40.9) |
| Working status | | | | |
| Employed | 158 (25.6) | 1,333 (42.3) | 826 (31.3) | 6,368 (44.5) |
| Unemployed | 29 (4.7) | 111 (3.5) | 72 (2.7) | 468 (3.3) |
| Retired | 429 (69.6) | 1,699 (53.9) | 1,732 (65.6) | 7,453 (52.1) |
| Education level | | | | |
| < Secondary school | 20 (3.2) | 77 (2.4) | 188 (7.1) | 590 (4.1) |
| Secondary school | 51 (8.3) | 195 (6.2) | 316 (12.0) | 1,275 (8.9) |
| Post-secondary degree/diploma | 541 (87.8) | 2,870 (91.1) | 2,134 (80.9) | 12,436 (86.9) |
| Area of residence | | | | |
| Rural | 58 (9.4) | 310 (9.8) | 365 (13.8) | 1,849 (12.9) |
| Urban | 551 (89.4) | 2,799 (88.9) | 2,239 (84.8) | 12,303 (85.9) |
| Province | | | | |
| Quebec | 65 (10.6) | 365 (11.6) | 536 (20.3) | 3,199 (22.3) |
| British Columbia | 189 (30.7) | 996 (31.6) | 538 (20.4) | 2,736 (19.1) |
| Ontario | 169 (27.4) | 869 (27.6) | 551 (20.9) | 2,920 (20.4) |
| Other* | 193 (31.3) | 920 (29.2) | 1,014 (38.4) | 5,463 (38.2) |
| Medical Conditions | | | | |
| Living with pain | 226 (36.7) | 944 (30.0) | 1,055 (40.0) | 4,260 (29.8) |
| Bowel disorders | 41 (6.7) | 227 (7.2) | 224 (8.5) | 1,135 (7.9) |
| Arthritis | 16 (2.6) | 83 (2.6) | 109 (4.1) | 355 (2.5) |
| Heart disease | 370 (60.1) | 1,007 (32.0) | 1,552 (58.8) | 4,353 (30.4) |
| Kidney disease | 36 (5.8) | 66 (2.1) | 111 (4.2) | 292 (2.0) |
| Stroke | 11 (1.8) | 36 (1.1) | 65 (2.5) | 157 (1.1) |
| Cancer | 95 (15.4) | 475 (15.1) | 465 (17.6) | 2,005 (14.0) |
| Hypertension | 355 (57.6) | 1,081 (34.3) | 1,530 (58.0) | 4,851 (33.9) |
| Anxiety disorder | 17 (2.8) | 109 (3.5) | 137 (5.2) | 606 (4.2) |
| Alcohol consumption | | | | |
| Never | 92 (14.9) | 309 (9.8) | 340 (12.9) | 1,209 (8.4) |
| About once a month | 141 (22.9) | 514 (16.3) | 608 (23.0) | 2,255 (15.7) |
| 2-4 times a month | 115 (18.7) | 576 (18.3) | 588 (22.3) | 3,160 (22.1) |

| | | | | |
|---|---|---|---|---|
| > 2 times a week | 239 (38.8) | 1,641 (52.1) | 1,031 (39.1) | 7,433 (51.9) |
| Smoking status | | | | |
| Non smoker | 297 (48.2) | 1,691 (53.7) | 1,088 (41.2) | 7,184 (50.2) |
| Former smoker | 275 (44.6) | 1,291 (41.0) | 1,348 (51.1) | 6,029 (42.1) |
| Smoker | 44 (7.1) | 168 (5.3) | 203 (7.7) | 1,105 (7.7) |
| Sleep quality | | | | |
| Satisfied or very satisfied | 373 (60.6) | 2,014 (63.9) | 1,615 (61.2) | 9,114 (63.7) |
| Neutral | 116 (18.8) | 513 (16.3) | 388 (14.7) | 2,158 (15.1) |
| Dissatisfied or very dissatisfied | 127 (20.6) | 617 (19.6) | 635 (24.1) | 3,038 (21.2) |
| Nutritional risk status | | | | |
| Low risk | 394 (64.0) | 2,256 (71.6) | 1,577 (59.8) | 10,128 (70.7) |
| High risk | 201 (32.6) | 796 (25.3) | 1,008 (38.2) | 3,919 (27.4) |
| Weight classification† | | | | |
| Normal weight | 112 (18.2) | 1,193 (37.9) | 383 (14.5) | 4,827 (33.7) |
| Overweight | 248 (40.3) | 1,312 (41.7) | 967 (36.6) | 6,086 (42.5) |
| Obese | 253 (41.1) | 638 (20.3) | 1,277 (48.4) | 3,365 (23.5) |

Diabetes was assessed with Hb1Ac ≥ 7% and/or a positive answer to “Has a doctor ever told you that you have diabetes, borderline diabetes or that your blood sugar is higher?”

* Other provinces are Alberta, Manitoba, Nova Scotia, Prince Edward Island, Labrador and Saskatchewan.

† Based on Body Mass Index international classification for adults ≥ 18 years of age.

Overall, 339 (10.4%) of people with diabetes had depression at 3 years, compared with 1465 (8.4%) people without diabetes. Among immigrants and nonimmigrants, respectively, 60 (9.7%) and 279 (10.6%) of those with baseline diabetes had depression at 3 years, compared with 265 (8.4%) and 1200 (8.4%), respectively, of those without baseline diabetes (Table 2).

Table 2. Three-year incidence and risk of depression, stratified by immigration and diabetes status

| | Depression Incidence | | | Weighted Crude OR (95% CI) | Adjusted Weighted OR (95% CI)* |
|---|---|---|---|---|---|
| Immigrant, N (%) | | | | | Diabetes vs. No Diabetes |
| | Yes | No | Total | | |
| Diabetes | 60 (9.7) | 556 (90.3) | 616 | 1.19 (0.86 - 1.65) | |
| No Diabetes | 265 (8.4) | 2,885 (91.6) | 3,150 | | |
| Total | 325 | 3,441 | 3,766 | | |
| Non-immigrant, N (%) | | | | | 1.18 (1.01 - 1.37) |
| | Yes | No | Total | | |
| Diabetes | 279 (10.6) | 2,360 (89.4) | 2,639 | 1.35 (1.15 - 1.57) | |
| No Diabetes | 1,200 (8.4) | 13,035 (91.6) | 14,318 | | |
| Total | 1,479 | 15,478 | 16,957 | | |
| **Interaction effect of immigrant status and diabetes at baseline** | | | | | |
| Immigrant with Diabetes versus immigrant with No Diabetes | | | | | 1.12 (0.80 - 1.56) |
| Immigrant with Diabetes versus non-immigrant with Diabetes | | | | | 1.01 (0.72 - 1.41) |
| Immigrant with No Diabetes versus non-immigrant with No Diabetes | | | | | 1.15 (0.98 - 1.35) |
| Non-immigrant with Diabetes versus non-immigrant with No Diabetes | | | | | 1.27 (1.08 - 1.49) |

OR= Odds Ratio; CI= Confidence Interval; Survey weights were provided by CLSA.
* The model included all the variables listed in Appendix, Table 1. The variables that were not significant (p-value > 0.05) were removed. Sex, age, immigration status and province were forced in the model. Diabetes was assessed at baseline with Hb1Ac ≥ 7% and/or a positive answer to "Has a doctor ever told you that you have diabetes, borderline diabetes or that your blood sugar is higher?" At 3-year follow-up, depression was defined using CES-D-10 score ≥ 10 and/or currently taking medication for depression for Cohort 1. The full model is available in Appendix, Table 2.

In multivariable logistic regression models (Table 2), individuals with baseline diabetes had 18% higher odds of depression at 3 years than those without baseline diabetes (adjusted OR 1.18, 95% CI 1.01-1.37). Among nonimmigrants, baseline diabetes was associated with 27% increased odds of depression at 3 years (adjusted OR 1.27, 95% CI 1.08-1.49), whereas no significant association was observed among immigrants (adjusted OR 1.12, 95% CI 0.80-1.56).

Depression at 3 years was associated with being female, living with pain, current smoking (versus past or never), weight change in the previous year (loss or gain), living in Quebec (versus Ontario or British Columbia), being younger (45-60 versus 61-70 yr) and not being satisfied with sleep (Appendix 1, Table 3).

Table 3. Baseline characteristics of Cohort 2 individuals with and without depression by immigration status

| | Immigrant (N= 3,913) | | Non-immigrant (N= 18,141) | |
|---|---|---|---|---|
| | Depression (N= 762) | No Depression (N= 3,151) | Depression (N= 3,797) | No Depression (N= 14,344) |
| | N (%) | | N (%) | |
| Age, y | | | | |
| 45-60 | 325 (42.7) | 1,173 (37.2) | 1,941 (51.1) | 7,053 (49.2) |
| 61-70 | 235 (30.8) | 1,048 (33.3) | 1,087 (28.6) | 4,228 (29.5) |
| 71-85 | 202 (26.5) | 930 (29.5) | 769 (20.3) | 3,063 (21.4) |
| Sex | | | | |
| Male | 266 (34.9) | 1,741 (55.3) | 1,351 (35.6) | 7,175 (50.0) |
| Female | 496 (65.1) | 1,410 (44.7) | 2,446 (64.4) | 7,169 (50.0) |
| Marital status | | | | |
| Single | 68 (8.9) | 149 (4.7) | 485 (12.8) | 1,178 (8.2) |
| Married | 465 (61.0) | 2,403 (76.3) | 2,223 (58.5) | 10,417 (72.6) |
| Widowed/divorced/separated | 227 (29.8) | 598 (19.0) | 1,088 (28.7) | 2,745 (19.1) |
| Language most spoken at home | | | | |
| French | 65 (8.5) | 205 (6.5) | 925 (24.4) | 3,174 (22.1) |
| English | 597 (78.3) | 2,598 (82.5) | 2,861 (75.3) | 11,137 (77.6) |
| Other | 58 (7.6) | 254 (8.1) | 7 (0.2) | 17 (0.1) |
| Ethnic/racial background | | | | |
| White | 629 (82.5) | 2,641 (83.8) | 3,758 (99.0) | 14,191 (98.9) |
| Black | 24 (3.1) | 89 (2.8) | 8 (0.2) | 19 (0.1) |
| South Asian | 36 (4.7) | 122 (3.9) | 2 (0.1) | 6 (0.0) |
| Chinese | 17 (2.2) | 107 (3.4) | 7 (0.2) | 37 (0.3) |
| Other | 53 (7.0) | 188 (6.0) | 20 (0.5) | 81 (0.6) |
| Years since arrival to Canada | | | | |
| < 20 | 112 (14.7) | 395 (12.5) | - | - |
| 20-40 | 190 (24.9) | 783 (24.8) | - | - |
| > 40 | 460 (60.4) | 1,973 (62.6) | - | - |

| | | | | |
|---|---|---|---|---|
| Total household income (CAD$) | | | | |
| < 20,000 | 57 (7.5) | 82 (2.6) | 332 (8.7) | 436 (3.0) |
| 20,000-50,000 | 208 (27.3) | 591 (18.8) | 923 (24.3) | 2,443 (17.0) |
| 50,000-100,000 | 246 (32.3) | 1,075 (34.1) | 1,217 (32.1) | 4,794 (33.4) |
| > 100,000 | 194 (25.5) | 1,180 (37.4) | 1,088 (28.7) | 5,854 (40.8) |
| Working status | | | | |
| Employed | 297 (39.0) | 1,332 (42.3) | 1,510 (39.8) | 6,373 (44.4) |
| Unemployed | 71 (9.3) | 111 (3.5) | 313 (8.2) | 468 (3.3) |
| Retired | 393 (51.6) | 1,701 (54.0) | 1,964 (51.7) | 7,474 (52.1) |
| Education level | | | | |
| < Secondary school | 30 (3.9) | 76 (2.4) | 260 (6.8) | 595 (4.1) |
| Secondary school | 64 (8.4) | 196 (6.2) | 367 (9.7) | 1,278 (8.9) |
| Post-secondary degree/diploma | 664 (87.1) | 2,871 (91.1) | 3,166 (83.4) | 12,454 (86.8) |
| Area of residence | | | | |
| Rural | 75 (9.8) | 310 (9.8) | 453 (11.9) | 1,850 (12.9) |
| Urban | 674 (88.5) | 2,800 (88.9) | 3,293 (86.7) | 12,328 (85.9) |
| Province | | | | |
| Quebec | 111 (14.6) | 365 (11.6) | 922 (24.3) | 3,204 (22.3) |
| British Columbia | 227 (29.8) | 995 (31.6) | 665 (17.5) | 2,735 (19.1) |
| Ontario | 223 (29.3) | 872 (27.7) | 855 (22.5) | 2,921 (20.4) |
| Other* | 201 (26.4) | 919 (29.2) | 1,355 (35.7) | 5,484 (38.2) |
| Medical conditions | | | | |
| Living with pain | 366 (48.0) | 945 (30.0) | 1,904 (50.1) | 4,267 (29.7) |
| Bowel disorders | 105 (13.8) | 227 (7.2) | 582 (15.3) | 1,136 (7.9) |
| Arthritis | 28 (3.7) | 83 (2.6) | 160 (4.2) | 354 (2.5) |
| Heart disease | 280 (36.7) | 1,009 (32.0) | 1,442 (38.0) | 4,364 (30.4) |
| Kidney disease | 17 (2.2) | 67 (2.1) | 109 (2.9) | 294 (2.0) |
| Stroke | 15 (2.0) | 37 (1.2) | 67 (1.8) | 157 (1.1) |
| Cancer | 117 (15.4) | 474 (15.0) | 573 (15.1) | 2,012 (14.0) |
| Hypertension | 283 (37.1) | 1,080 (34.3) | 1,457 (38.4) | 4,870 (34.0) |
| Anxiety disorder | 119 (15.6) | 109 (3.5) | 919 (24.2) | 611 (4.3) |
| Alcohol consumption | | | | |
| Never | 101 (13.3) | 310 (9.8) | 528 (13.9) | 1,218 (8.5) |
| About once a month | 171 (22.4) | 512 (16.2) | 756 (19.9) | 2,259 (15.7) |
| 2-4 times a month | 150 (19.7) | 574 (18.2) | 827 (21.8) | 3,166 (22.1) |
| > 2 times a week | 310 (40.7) | 1,645 (52.2) | 1,625 (42.8) | 7,436 (51.8) |
| Smoking status | | | | |
| Non smoker | 377 (49.5) | 1,690 (53.6) | 1,644 (43.3) | 7,200 (50.2) |
| Former smoker | 315 (41.3) | 1,293 (41.0) | 1,690 (44.5) | 6,040 (42.1) |
| Smoker | 70 (9.2) | 168 (5.3) | 463 (12.2) | 1,104 (7.7) |
| Sleep quality | | | | |
| Satisfied or very satisfied | 339 (44.5) | 2,014 (63.9) | 1,692 (44.6) | 9,133 (63.7) |
| Neutral | 132 (17.3) | 513 (16.3) | 588 (15.5) | 2,162 (15.1) |
| Dissatisfied or very dissatisfied | 291 (38.2) | 618 (19.6) | 1,512 (39.8) | 3,041 (21.2) |

| | | | | |
|---|---|---|---|---|
| Nutritional risk status | | | | |
| Low risk | 381 (50.0) | 2,256 (71.6) | 1,772 (46.7) | 10,147 (70.7) |
| High risk | 356 (46.7) | 797 (25.3) | 1,941 (51.1) | 3,924 (27.4) |
| Weight classification† | | | | |
| Normal weight | 264 (34.6) | 1,194 (37.9) | 1,205 (31.7) | 4,838 (33.7) |
| Overweight | 310 (40.7) | 1,313 (41.7) | 1,423 (37.5) | 6,094 (42.5) |
| Obese | 184 (24.1) | 637 (20.2) | 1,144 (30.1) | 3,372 (23.5) |

Depression was assessed with Center for Epidemiological Studies Depression 10 Scale, CES-D ≥ 10 and/or currently undergoing treatment for depression.
* Other provinces are Alberta, Manitoba, Nova Scotia, Prince Edward Island, Labrador and Saskatchewan.
† Based on Body Mass Index international classification for adults ≥ 18 years of age.

*Depression at baseline and risk of diabetes at 3 years*

Cohort 2 included 22,054 individuals (Figure 1), including 3913 (17.7%) immigrants (Table 3). Among immigrants, 762 (19.5%) had depression at baseline, compared with 3797 (20.9%) nonimmigrants. In general, baseline characteristics between individuals with or without baseline depression were similar in immigrants and in nonimmigrants (Appendix 1, Table 4).

Overall, 311 (6.8%) individuals with depression at baseline developed diabetes, compared with 837 (4.8%) of those without depression (Table 4). Among immigrants and nonimmigrants, respectively, 54 (7.1%) and 257 (6.8%) of those with depression at baseline developed diabetes, compared with 144 (4.6%) and 693 (4.8%) of those without depression at baseline.

In multivariable logistic regression models (Table 4), those with depression at baseline had 43% higher odds to develop diabetes than those without depression (adjusted OR 1.43, 95% CI 1.21-1.68). Among nonimmigrants, depression was associated with 39% increased odds of diabetes (adjusted OR 1.39, 95% CI 1.16-1.68); among immigrants, depression was associated with a 60% increased odds of diabetes (adjusted OR 1.60, 95% CI 1.08-2.37).

Table 4. Three-year incidence and risk of diabetes, stratified by immigration and depression status

| | Diabetes Incidence | | | Weighted Crude OR (95% CI) | Adjusted Weighted OR (95% CI)* |
|---|---|---|---|---|---|
| Immigrant, N (%) | | | | | Depression vs. No Depression |
| | Yes | No | Total | | |
| Depression | 54 (7.1) | 708 (92.9) | 762 | 1.66 (1.16 - 2.39) | |
| No Depression | 144 (4.6) | 2,970 (95.4) | 3,151 | | |
| Total | 198 | 3,715 | 3,913 | | |
| Non-immigrant, N (%) | | | | | 1.43 (1.21 - 1.68) |
| | Yes | No | Total | | |
| Depression | 257 (6.8) | 3,540 (93.2) | 3,797 | 1.55 (1.31 - 1.82) | |
| No Depression | 693 (4.8) | 13,651 (95.2) | 14,344 | | |
| Total | 950 | 17,191 | 18,141 | | |
| **Interaction effect of immigrant status and depression at baseline** | | | | | |
| Immigrant with Depression versus immigrant with No Depression | | | | | 1.60 (1.08 - 2.37) |
| Immigrant with Depression versus non-immigrant with Depression | | | | | 1.10 (0.76 - 1.58) |
| Immigrant with No Depression versus non-immigrant with No Depression | | | | | 0.96 (0.76 - 1.21) |
| Non-immigrant with Depression versus non-immigrant with No Depression | | | | | 1.39 (1.16 - 1.68) |

OR= Odds Ratio, CI= Confidence Interval; Survey weights were provided by CLSA.
* The model included all the variables listed in Appendix, Table 3. The variables that were not significant (p-value > 0.05) were removed. Sex, age, immigration status and province were forced in the model. Depression was assessed with Center for Epidemiological Studies Depression 10 Scale, CES-D ≥ 10 and/or currently undergoing treatment for depression. Three-year incident diabetes was defined using self-reported diabetes diagnosis and/or currently taking medication for diabetes. The full model is available in Appendix, Table 2.

Overall, diabetes at 3 years was associated with being male, being younger (45-60 versus 71-85 yr), having hypertension, having heart disease, high waist circumference and weight change (versus same weight) (Appendix 1, Table 3).

Results of both sensitivity analyses were similar to those of the main analyses (Appendix 1, Table 2, Table 5, Table 6).

## Interpretation

Our study provides evidence for a bidirectional association between diabetes and depression in the population aged 45 years and older. Overall, diabetes at baseline was associated with an increased risk of depression at 3-year follow-up, and depression at baseline was associated with an increased risk of diabetes at 3-year follow-up. In general, immigration status did not modify these risks in either direction. Specifically, although depression was associated with 39% and 60% increased odds of diabetes among nonimmigrants and immigrants, respectively, the overlapping 95% CIs did not suggest a conclusive modifying effect by immigration status. Moreover, although diabetes at baseline was associated with 27% increased odds of depression among nonimmigrants and a nonsignificant increase by 12% among immigrants, a modification effect by immigration status could not be concluded.

We had expected to observe differences in the bidirectional relation between diabetes and depression by immigration status because of the complex social determinants of health and stressors (24) that immigrants live with and how these may potentially be associated with low-grade inflammation (128, 373, 374). The lack of effect modification by immigration status in the diabetes–depression relation in our study may perhaps be explained by the resilience of immigrants in their dynamic process of positive adaptation (80, 375).

We did not find any published study that assessed depression incidence in immigrants and nonimmigrants with or without diabetes. Results from 2 meta-analyses evaluating the association between diabetes and depression incidence found a 24% increased risk of depression among people with diabetes, similar to our finding for immigrants and nonimmigrants combined (240, 376). Higher risks of depression were also reported, with increased risks of macrovascular and microvascular complications of diabetes (238). However, this could not be investigated in our study as diabetes complications were not specifically available in our data.

We found that nonimmigrants with diabetes were at 27% increased odds of depression at 3 years, whereas we did not observe a significant difference among immigrants. Most of the immigrants in our cohorts were white and had resided in Canada for more than 20 years, which may explain the lack of association (199).

In our study, the 43% increased risk of developing diabetes in individuals with depression is close to the 34% increase in pooled risk reported by a meta-analysis (240). The meta-analysis

included cohort, cross-sectional and case–control studies that considered both prevalent and incident diabetes, in contrast to our study, which considered only incident diabetes. The increased risk of diabetes among people with depression has been attributed to lack of compliance with dietary and weight loss recommendations (377). Furthermore, antidepressant use may affect cortisol pathways that stimulate weight gain, and in turn lead to diabetes (348, 349). Risk factors for diabetes in our study were similar to those reported in other studies (378, 379).

Among individuals older than 45 years, regardless of immigration status, we suggest that clinicians screen for depression in those with diabetes and for diabetes in those with depression as early detection may prevent complications. This suggestion is supported by the Canadian Collaboration for Immigrant and Refugee Health clinical guideline (83, 380).

*Limitations*

Strengths of our study include the use of high-quality data from the carefully designed, longitudinal, population-based CLSA database. Our study also used a longitudinal design and direct measurement of depressive symptoms (CES-D-10) or treatment for depression, and diabetes (self-reported diagnosis and $HbA_{1c}$ at baseline). Nonetheless, it has some limitations. Although we used survey weights in our analyses, participation bias cannot be ruled out (334). In addition, the CES-D-10 tool and the definition of diabetes use self-reported information that come with measuring errors and information bias (337). These errors may have differed between immigrants and nonimmigrants because of possible language barriers and culture-related social desirability (381). Furthermore, diabetes at follow-up was identified by self-report only because CLSA laboratory data were not available at that time point. However, this likely did not affect our results because the proportion of people identified as having diabetes solely by laboratory data is expected to be very small (about 2% at baseline). Information on complications of diabetes was not available in the database; poor glycemic control (382) and increased risk of complications (238) may increase the risk of depression.

We did not differentiate by diabetes type because about half of participants declared not knowing their diabetes type (reported neither type 1 nor type 2) and only 2.6% at baseline and 0.6% in follow-up of people with diabetes at these time points declared having type 1 diabetes. Around 87% and 63% of immigrants in our cohort were in Canada for more than 20 years and

over 40 years, respectively. Therefore, generalizability of our results to recently arrived immigrants should be done with caution. Despite the large overall sample size, confidence intervals for interaction effects were wide, and thus modest effect modification cannot be ruled out.

Finally, a small number (1.5%) of the CLSA participants were not white, and hence, we were unable to evaluate ethnic subgroups (91-93, 240). The proportion of immigrants and nonimmigrants in our study who were not white ($n$ = 1140, 4.1%) was lower than the proportion of visible minorities in Canada (19.1%) reported in 2011 (383). Population cohorts are based on voluntary participation and participants may be different from nonparticipants (384). However, our study lacks information on nonparticipants, and generalizability of our results to visible minority groups should be done with caution (385).

*Conclusion*

We found an overall bidirectional association between diabetes and depression that was not significantly modified by immigration status. Although the association between diabetes and depression was statistically significant in both directions among nonimmigrants, only one direction (depression predicting diabetes) was statistically significant among immigrants. Future studies should investigate the bidirectional association of diabetes and depression among recently arrived immigrants and those of visible minority groups.

## Chapter VI: Determinants of loss to follow-up in the Canadian longitudinal study on aging: a retrospective cohort study

Preamble of Manuscript 3

In my second manuscript, I assessed the role of depression status as a risk factor for the development of diabetes over a period of three years and the role of diabetes status as a risk factor for the development of depression over a period of three years in immigrants and non-immigrant. Amongst non-immigrants, I found that diabetes increased the risk of depression by 39% and depression increased the risk of diabetes by 60%. Amongst immigrants, I found that depression increased the risk of diabetes by 12% over the same time-period, but the effect of diabetes on the risk of depression was not statistically significant.

My findings are similar to those of published studies showing a strong and consistent association between depression status and diabetes incidence and a weak and inconsistent association between diabetes status and depression in the general population. The increased risk of undiagnosed depression that I found in my first manuscript among immigrants vs non-immigrants and the increased risk of diabetes that I found among those with depression in my second manuscript may perhaps explain some of the higher risk of diabetes reported in the literature among immigrants vs non-immigrants.

In my first and second manuscripts, I used a cohort design and data collected prospectively over 18-month and 3-year time-periods, respectively. In longitudinal data collection, loss to follow-up is an obstacle to research that may modify the cohort composition and lead to biased results if not well-addressed in the analyses. In my third manuscript, I examined this important methodological issue and its implications in the CLSA data.

Post-immigration, immigrant experience a shift in cultural systems, rebuilding of social networks, and language barriers (386). Communication difficulties has been associated with social isolation, likelihood of living in poverty, having lower perceived health status, and chronic diseases (24). Immigrants also tend to have more socio-economic and life challenges than non-immigrants that might prevent them from continuing in a cohort study. Little is known about loss to follow-up risks

in longitudinal studies among participants who belong to vulnerable groups including immigrants, those with depressive symptoms and those with sub-optimal levels of language proficiency. Systematic loss to follow-up creates selection bias and hinders generalizability in cohort studies.

Given the intrinsic role of language proficiency in an individual's life and my previous findings regarding the higher risk of depressive symptoms in immigrants, I evaluated the effect of depressive symptoms, immigrant status and language on the 3-year loss to follow-up in the CLSA database. This study has been published in *BMJ Epidemiology and Community Health* on September 22nd, 2022.

Farid D, Li P, Dasgupta K, and Rahme E. Determinants of loss to follow-up in the Canadian longitudinal study on aging: a retrospective cohort study. *J Epidemiol Community Health* 2022;76:1011-1018.

**Determinants of loss to follow-up in the Canadian longitudinal study on aging: a retrospective cohort study**


## Abstract

**Background:** Systematic loss to follow-up (LFU) creates selection bias and hinders generalizability in longitudinal cohort studies. Little is known about LFU risks in underserved populations including immigrants, those with depressive symptoms and language minorities. We used the Canadian Longitudinal Study on Aging (baseline 2012-2015 and 3-year follow-up 2015-2018) Comprehensive and Tracking cohorts to examine the association of language with LFU and its effect modification by immigrant status and depressive symptoms among participants from Quebec and those from outside Quebec.

**Methods:** Language was English-speaking, French-speaking, and Bilingual according to the language participants' reported being able to converse in. Language minorities were French-speakers outside Quebec and English-speakers inside Quebec. LFU was withdrawal or not providing follow-up data. Logistic regression models assessed the associations of interest.

**Results:** Our cohort included 49,179 individuals (mean age 63.0, SD 10.4 years; 51.4% female) Overall, 7,808 (15.9%) were immigrants and 7,902 (16.1%) had depressive symptoms. Language was 4,672 (9.5%) French-speaking, 33,532 (68.2%) English-speaking and 10,976 (22.3%) Bilingual. Immigration ≤20 years (odds ratio 1.84, 95% confidence interval 1.34-2.53) or arrival at age >22 years (1.32, 1.10-1.58) and depressive symptoms (1.23, 1.13-1.46) had higher LFU risks. Bilingual (versus French-speaking) had lower LFU risk outside (0.45, 0.24-0.86) and inside Quebec (0.78, 0.63-0.98). LFU risk was higher in French-speakers (versus English-speakers) outside (2.33, 1.19-4.55), but not inside Quebec. Female, higher income, higher education, and low nutritional risk had lower LFU risks.

**Conclusion:** Speaking only French (versus Bilingual), having depressive symptoms and immigrant status increased LFU risks, with the latter not modifying the language effect.

## Key Messages

**What is already known on this topic**?

1. Loss to follow-up of participants in prospective cohort studies may bias study results.
2. Mental illness can lead to higher loss to-follow-up in cohort studies.
3. Language has been identified as a determinant of mental health, but its association with loss to follow-up has not been studied.

**What this study adds?**

1. Immigrants with ≤20 years of residency at recruitment and those who arrived to Canada at age >22 years may be at higher risk of loss to follow-up than non-immigrants.
2. Participants with depressive symptoms at recruitment may be at higher risk of loss to follow up than those without such symptoms.
3. Conversing in only one official language may be a risk factor for loss to follow-up in prospective cohort study.

**How this study might affect research, practice or policy?**

1. Immigrants with a relatively shorter duration since arrival, older-aged immigrants at arrival, participants with depressive symptoms and those speaking only one of the official languages have higher risks of loss to follow-up in prospective cohort studies.
2. Retention strategies need to consider these factors to avoid selection bias.

## Background

Prospective cohort studies are of major importance in evaluating population health and identifying risk factors related to adverse health outcomes (387). However, loss to follow-up (LFU) can be a major threat to their internal and external validity (100). When LFU is random, the reduced sample size decreases the statistical power, but when LFU is non-random, it alters sample composition, potentially resulting in biased findings (99, 388).

Previous studies have identified sociodemographic, lifestyle and health factors associated with increased LFU risks in prospective studies (389-392). These included age, non-white ethnicity, male sex, limited education and poor self-reported health. Higher LFU has also been reported among retired and unmarried study participants and among those with unhealthy lifestyle habits (heavy drinking, substance abuse, and eating disorders) (389, 390). Mood disorders including depression also increase LFU risks in cohort studies (388).

Being part of potentially underserved populations, such as language minority and immigrant groups may also affect LFU (393). In Canada, French is predominantly spoken in Quebec and English is predominantly spoken in all other provinces (outside Quebec). In 2016, French-speaking minorities (French as mother tongue) outside Quebec and English minorities in Quebec represented 3.8% and 4.6% of the respective populations (394). Based on the Canadian Community Health Survey (2001-2003), French-speaking minorities outside Quebec had lower socio-economic status (SES), lower education attainment, and higher likelihood of rural living, communication difficulties, and social exclusion than their English-speaking counterparts (104, 395, 396); factors that have been associated with increased LFU risk in prospective cohort studies. A Canadian prospective study has also reported higher LFU among immigrants compared to Canadian-born citizens (264). Reasons for this increased LFU among immigrant have yet to be well studied, although language barriers, lower SES, and higher rates of depression among immigrants could be important contributors (83, 339).

We aimed to determine 1) the impact of language (English-speaking, French-speaking or Bilingual) on the risk of 3-year LFU in the Canadian Longitudinal Study on Aging (CLSA) and 2) to investigate whether this impact is modified by immigration status (time of residency and age at arrival) and baseline depressive symptoms.

## Methods

### *Data source and study design*

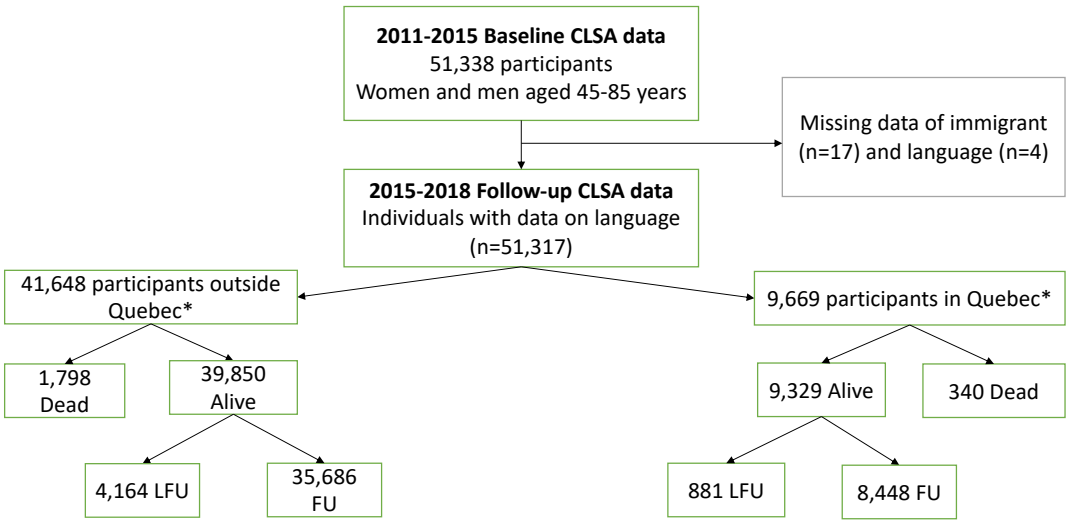
We used the CLSA Comprehensive (n= 30,097) and Tracking cohorts' (n= 21,241) baseline (2012-2015) and 3-year follow-up (2015-2018) data. Both cohorts included community dwelling individuals, ages 45-85 years at enrolment. Participants were randomly selected from the population using three sampling frames: 1) a subset of Statistic's Canada's Canadian Community Health Survey-Healthy Aging (CCHS-HA); 2) the registries of provincial health care systems; and 3) Random Digit Dialing of landline telephones. For better representation of people with less education and lower socio-economic status, efforts were made to over-sample in under-represented areas (105, 272). The overall participation rate for the CLSA was approximately 45%, and response rate was 10% (105). The CLSA excluded residents of the Canadian territories (Yukon, Nunavut and Northwest) and some remote regions including Federal First Nations reserves and other provincial First Nations settlements, full-time members of the Canadian Armed Forces, and institutionalized persons. Participants completed the questionnaires in either English or French and were physically and cognitively able to participate on their own (105, 272). In addition to the baseline and 3-year follow-up assessments, data collection was supplemented with a brief inter-assessment telephone interview, the Maintaining Contact Questionnaires (MCQ) at 18 months, to collect some additional data, update contact information, and minimize loss to follow-up. The Tracking cohort was a random sample from the ten provinces and was interviewed by telephone, while the Comprehensive cohort was a random sample from those who lived within 25–50 km of 11 data collection sites (seven provinces) and was interviewed in person. In addition, the Comprehensive cohort participants underwent on-site physical and cognitive assessments and provided blood and urine specimen (105, 272). Sampling weights were calculated by CLSA for the combined Tracking and Comprehensive cohorts as well as for each one of these cohorts separately. The interview questionnaire was common to both cohorts. Details about the CLSA's sampling, design, recruitment, and data collection have been published elsewhere (105).

### *Cohort definition and exclusion criteria*

Our study cohort consisted of the CLSA Comprehensive and Tracking cohorts combined, excluding those with missing information on immigration status, language 'you can converse with' and those who were deceased at follow-up (n= 2,138) (Figure1). Participants' death was

ascertained by CLSA from linkage with the vital statistics data available from Statistics Canada and communication with the next of kin.

Figure 1: Flow chart depicting the construction of the study cohort




*Outside Quebec refers to the provinces outside of the French-speaking majority Quebec (Ontario, British Columbia, Alberta, Manitoba, Nova Scotia, Prince Edward Island, Newfoundland and Labrador, Saskatchewan). CLSA: Canadian Longitudinal Study on Aging. FU= Follow-up; LFU= Loss to follow-up or withdrawn at 3 years.

*Exposure of interest assessed at baseline*

We defined the linguistic status using the question "What is the language that you can converse with?". We categorized the response into English-speaking (English with or without any other language but no French), French-speaking (French with or without any other language but no English) and Bilingual (both English and French with or without any other language). Language effect on LFU may depend on the province of residence, hence, we categorized province into Quebec (French-speaking majority), and outside Quebec (English-speaking majority including all Canadian provinces but Quebec). We defined depressive symptoms at baseline using the validated Center for Epidemiological Studies Depression 10 Scale (CES-D-10) score≥ 10 (214, 312). We used the CLSA classification for immigrant status established based on the questions "In what country were you born?" and "In what year did you first come to Canada to live?"(351). We dichotomized immigrant's residency time in Canada into ≤20 and >20 years, as a Canadian study

found that immigrants' mental health improve after 20 years (37). We also investigated the effect of immigrants' age at arrival in Canada (pre and post- university years, ≤22 and >22 years old).

*Study outcomes*

Our outcome was LFU assessed at three years. We defined LFU as being alive but having either withdrawn from the study or did not provide follow-up data (n=4,688).

*Baseline characteristics*

We assessed the following baseline characteristics because of their possible association with the exposures of interest and LFU (397-399): sociodemographic and socioeconomic factors: sex, age (45-60, 61-70 and 71-85 years), ethnic/racial background (White, Black, South Asian, Chinese and Other), social support (high/low) based on Medical Outcome Study Social Support survey (313), marital status (widowed/divorced/separated, married, or single), household income (Can$, <20,000; 20,000-50,000; 50,000-100,000 and >100,000), employment status (employed, unemployed and completely or partly retired), education (post-secondary, <post-secondary), and area of residence (urban or rural/suburban) (313). We also considered the following medical conditions: living with pain, history of cancer, arthritis, bowel disorders, diabetes, heart disease, and hypertension (264, 397-399); and health behaviours and anthropometric factors: past-year alcohol consumption (never, 1-4 times/month, ≥2 times/week) (389), smoking status (current, former and never) (390), nutritional risk score using AB SCREEN$^{TM}$ II (high and low) (400), weight status applying the World Health Organization classification for adults aged ≥18 years of body mass index (314) and weight change in the past 6-months. We also identified individuals by their CLSA cohort type (Comprehensive or Tracking). Cohort type was included because studies have suggested that using site and home visits for data collection may decrease the risk of LFU as compared to other methods of data collection (392, 401-403).

## Statistical analysis

We computed descriptive statistics to report baseline characteristics with means and standard deviations (SD) for continuous variables and counts with percentages for categorical

variables by province (Quebec and outside Quebec), and the three language categories (French-speaking, English-speaking, and Bilingual). We used multivariable, multinomial logistic regression models to compare these characteristics between language categories in Quebec and outside Quebec, respectively. We reported the numbers and proportions of the other main exposures of interests (immigrant status and depressive symptoms at baseline) and of the outcome LFU by language and province. We used multivariable logistic regression models to examine the association between language and LFU. Because of the inherent societal and language differences between Quebec and outside Quebec, we included an interaction term for language and province. Because the effect of language may differ by immigrant status, we separately examined the association between language and LFU risk in non-immigrant and immigrant (stratified by time of residence ≤20 years and >20 years). We also examined whether there was a modifying effect of depressive symptoms on the association between language and LFU by conducting separate analyses by baseline depressive symptoms. All models included sex, age and cohort type. Other variables listed in the Baseline characteristics section were included in the model. Among these, variables not significant (p-value >0.05) and which inclusion did not affect the Bayesian Information Criterion nor the effect of the main exposure variable by more than 10% were removed (368). Results were expressed in odds ratios (OR) with 95% confidence intervals (CI). All statistical analyses were performed using SAS software package Version 9.4 (SAS Institute Inc., Cary, North Carolina, USA).

*Ethics approval*

Ethics approval was provided by the McGill University Health Centre Research Ethics Board (application number 2020-6340).

## Results

*Descriptive analyses*

Our cohort included 49,179 individuals (mean age 63.0, SD 10.4 years; 51.4% female). Among these, 9,329 (19.0%) were living in Quebec and 16.1% had depressive symptoms at baseline (Figure 1, Supplemental Figure 1a, Supplemental Figure 1b, Table 1, and Table 2). Overall, 15.9% were immigrants, of whom 74.3% conversed in English only, 3.6% in French only, and 22.2%

conversed in both English and French individuals. Of immigrants, 87.4% resided >20 years in Canada and 52.9% were >22 years of age at arrival (Table 1).

**Table 1: Baseline characteristics* by language groups and province.**

| | In Quebec** | | | Outside Quebec | | |
|---|---|---|---|---|---|---|
| | French† (N= 4,552) | English minority (N=230) | Bilingual (N= 4,547) | French minority (N= 119) | English (N= 33,302) | Bilingual (N= 6,429) |
| | | N (%) | | | N (%) | |
| Age, y | | | | | | |
| 45-60 | 2,079 (45.7) | 56 (24.3) | 2,189 (48.1) | 58 (48.7) | 15,060 (45.2) | 3,088 (48.0) |
| 61-70 | 1,406 (30.9) | 77 (33.5) | 1,391 (30.6) | 33 (27.7) | 9,765 (29.3) | 2,045 (31.8) |
| 71-86 | 1,067 (23.4) | 97 (42.2) | 967 (21.3) | 28 (23.5) | 8,477 (25.5) | 1,296 (20.2) |
| Sex | | | | | | |
| Male | 1,885 (41.4) | 102 (44.3) | 2,503 (55.0) | 39 (32.8) | 16,163 (48.5) | 3,193 (49.7) |
| Female | 2,667 (58.6) | 128 (55.7) | 2,044 (45.0) | 80 (67.2) | 17,139 (51.5) | 3,236 (50.3) |
| Total household income | | | | | | |
| <20,000$ | 506 (11.1) | 33 (14.3) | 266 (5.9) | 21 (17.6) | 1,660 (5.0) | 218 (3.4) |
| 20,000-50,000$ | 1,617 (35.5) | 79 (34.3) | 1,119 (24.6) | 50 (42.0) | 7,510 (22.6) | 1,003 (15.6) |
| 50,000-100,000$ | 1,474 (32.4) | 68 (29.6) | 1,605 (35.3) | 27 (22.7) | 11,322 (34.0) | 2,021 (31.4) |
| >100,000$ | 661 (14.5) | 30 (13.0) | 1,320 (29.0) | 9 (7.6) | 10,630 (31.9) | 2,818 (43.8) |
| Working status | | | | | | |
| Employed | 1,580 (34.7) | 55 (23.9) | 1,887 (41.5) | 41 (34.5) | 13,360 (40.1) | 2,825 (43.9) |

| | | | | | | |
|---|---|---|---|---|---|---|
| Unemployed | 236 (5.2) | 8 (3.5) | 222 (4.9) | 10 (8.4) | 1,514 (4.5) | 248 (3.9) |
| Retired | 2,697 (59.2) | 163 (70.9) | 2,428 (53.4) | 68 (57.1) | 18,318 (55.0) | 3,336 (51.9) |
| Education level | | | | | | |
| < Post-secondary degree/diploma | 1,429 (31.4) | 60 (26.1) | 682 (15.0) | 41 (34.5) | 6,159 (18.5) | 507 (7.9) |
| Post-secondary degree/diploma | 3,123 (68.6) | 170 (73.9) | 3,865 (85.0) | 78 (65.5) | 27,143 (81.5) | 5,922 (92.1) |
| Setting | | | | | | |
| Rural | 1,537 (33.8) | 47 (20.4) | 1,044 (23.0) | 70 (60.5) | 6,679 (20.1) | 1,142 (17.8) |
| Urban | 2,981 (65.5) | 178 (77.4) | 3,468 (76.3) | 32 (26.9) | 24,631 (74.0) | 5,002 (77.8) |
| Medical Conditions | | | | | | |
| Living with pain | 2,028 (44.6) | 93 (40.4) | 1,764 (38.8) | 57 (47.9) | 11,659 (35.0) | 2,100 (32.7) |
| Bowel disorders | 308 (6.8) | 15 (6.5) | 328 (7.2) | 7 (5.9) | 3,340 (10.0) | 573 (8.9) |
| Diabetes | 769 (16.9) | 38 (16.5) | 649 (14.3) | 18 (15.1) | 5,773 (17.3) | 954 (14.8) |
| Arthritis | 87 (1.9) | 11 (4.8) | 104 (2.3) | 5 (4.2) | 1,475 (4.4) | 238 (3.7) |
| Heart Disease | 1,054 (23.2) | 55 (23.9) | 1,046 (23.0) | 13 (10.9) | 5,124 (15.4) | 974 (15.2) |
| Cancer | 507 (11.1) | 34 (14.8) | 551 (12.1) | 49 (41.2) | 12,289 (36.9) | 2,138 (33.3) |
| Hypertension | 1,760 (38.7) | 110 (47.8) | 1,643 (36.1) | 50 (42.0) | 13,076 (37.8) | 2,246 (34.0) |
| Alcohol consumption | | | | | | |
| Never | 423 (9.3) | 32 (13.9) | 308 (6.9) | 17 (15.6) | 4,309 (12.9) | 618 (9.8) |
| About 1-4 times a month | 2,104 (46.2) | 98 (42.6) | 1,684 (37.0) | 70 (64.2) | 14,192 (44.1) | 2,430 (38.5) |
| ≥2 times a week | 1,915 (42.1) | 87 (37.8) | 2,493 (54.8) | 22 (20.2) | 13,684 (42.5) | 3,271 (51.8) |
| Smoking Status | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Non-smoker | 1,526 (33.6) | 88 (38.3) | 1,593 (35.1) | 41 (34.5) | 13,752 (41.3) | 2,895 (45.0) |
| Former smoker | 1,462 (32.2) | 85 (37.0) | 1,704 (37.5) | 24 (20.2) | 9,316 (28.0) | 1,837 (28.6) |
| Smoker | 1,552 (34.2) | 57 (24.8) | 1,246 (27.4) | 54 (45.4) | 10,163 (30.5) | 1,686 (26.2) |
| Nutritional risk status | | | | | | |
| Low risk | 2,632 (57.8) | 127 (55.2) | 2,931 (64.5) | 66 (55.5) | 19,742 (59.3) | 4,204 (65.4) |
| High risk | 1,625 (35.7) | 87 (37.8) | 1,426 (31.4) | 38 (31.9) | 11,050 (33.2) | 1,863 (29.0) |

SD=standard deviation

*This Table presents the baseline characteristics that were significantly associated with loss to follow-up in our analyses. Additional characteristics that were also explored were: marital status, ethnicity, social support, seeing a psychologist in the past year, BMI, and weight change. The full Table is presented in the Supplemental Table 1a.

** Outside Quebec refers to all Canadian provinces other than Quebec.

†Language is defined using the language that "you can conduct a conversation with" coded as English-speaking only, French-speaking only or Bilingual. French-speaking individuals: can converse in French with or without any other language but English; English-speaking individuals: can converse in English with or without any other language but French; Bilingual: can converse in English and French with or without any other language.

**Table 2: Number of individuals and proportions for baseline depression, immigration status, and 3-year loss to follow-up by language groups and province**

| | In Quebec | | | Outside Quebec* | | |
|---|---|---|---|---|---|---|
| | French† (N= 4,552) | English minority (N= 230) | Bilingual (N=4,547) | French minority (N= 119) | English (N=33,302) | Bilingual (N=6,429) |
| | N (%) | | | | | |
| Baseline depression | | | | | | |
| Yes | 853 (18.7) | 43 (18.7) | 715 (15.7) | 28 (23.5) | 5,352 (16.1) | 911 (14.2) |
| No | 3,686 (81.0) | 186 (80.9) | 3,818 (84.0) | 90 (75.6) | 27,840 (83.6) | 5,500 (85.5) |
| Missing | 13 (0.3) | 1 (0.4) | 14 (0.3) | 1 (0.8) | 110 (0.3) | 18 (0.3) |
| Non-immigrant | 4,289 (94.2) | 122 (53.0) | 4,073 (89.7) | 104 (87.4) | 27,611 (82.9) | 5,172 (80.4) |
| Immigrant | 263 (5.8) | 108 (47.0) | 474 (10.4) | 15 (12.6) | 5,691 (17.1) | 1,257 (19.6) |
| Years since arrival to Canada | | | | | | |
| ≤20 years | 90 (2.0) | 11 (4.8) | 99 (2.2) | 9 (7.6) | 674 (2.0) | 103 (1.6) |
| >20 years | 173 (3.8) | 97 (42.2) | 375 (8.2) | 6 (5.0) | 5,017 (15.1) | 1,154 (17.9) |
| Age at arrival in Canada (years old) | | | | | | |
| ≤22 | 48 (1.1) | 44 (19.1) | 197 (4.3) | 1 (0.8) | 2,766 (8.3) | 385 (6.0) |

| | | | | | | |
|---|---|---|---|---|---|---|
| >22 | 215 (4.7) | 64 (27.8) | 277 (6.1) | 14 (11.8) | 2,925 (8.8) | 632 (9.8) |
| Loss to follow-up | | | | | | |
| Yes | 523 (11.5) | 32 (13.9) | 326 (7.2) | 29 (24.4) | 3,654 (11.0) | 481 (7.5) |
| No | 4,029 (88.5) | 198 (86.1) | 4,221 (92.8) | 90 (75.6) | 29,648 (89.0) | 5,948 (92.5) |

LFU= Loss to follow-up (withdrawn or did not provide data at 3-year follow-up).

*Outside Quebec refers to all Canadian provinces other than Quebec. †Language is defined using the language that "you can conduct a conversation with" coded as English-speaking only, French-speaking only or Bilingual. French-speaking individuals: can converse in French with or without any other language but English; English-speaking individuals: can converse in English with or without any other language but French; Bilingual: can converse in English and French with or without any other language. Depression is assessed with Center for Epidemiological Studies Depression 10 Scale, CESD ≥ 10.

In Quebec, around half (48.8%) of our study subjects were French-speaking, 2.5% English-speaking and 48.7% Bilingual (Supplemental Figure 1a and Supplemental Table 1a). Of the French-speaking individuals, 45.7%, were 45-60 years old compared to 48.1% of the Bilingual individuals, while the English-speaking individuals were older with only 24.3% being in the 45-60 year age-group. In all language categories, the majority were married, White, retired, had a post-secondary education degree, resided in urban settings, had low nutritional risk, were mostly overweight/obese, did not change weight in the past 6 months and belonged to the Comprehensive cohort (Supplemental Table 1b). In multinomial logistic regression models (Supplemental Table 1b), Bilingual versus French-speaking were more likely to be > 60 years old, male, immigrants, have income > $50,000 (versus < $20,000), unemployed, have a post-graduate education and part of the Comprehensive cohort. They were also more likely to consume alcohol and less likely to be living with pain. When comparing English-speaking to French-speaking individuals, only age and immigrant status were significantly higher among English-speaking individuals while alcohol consumption was lower.

Outside Quebec, 83.6% were English-speaking, 0.3% French-speaking and 16.1% Bilingual (Supplemental Figure 1b and Supplemental Table 1c). Almost half were in the 45-60 year age group in the three language categories. Most were married, White, retired, had a post-education degree, had low nutritional risk, were overweight/obese and did not change weight in the past 6 months. In multinomial logistic regression models (Supplemental Table 1b), Bilingual compared to English-speaking individuals were more likely 61-70 years old (versus 45-60), female, immigrants, with income > $100,000 (versus < $20,000), post-graduate education, to have lost weight in the past 6 months and to be part of the Comprehensive cohort. They were also more likely to have consumed alcohol and less likely to have high nutritional risk. When comparing French-speaking to English-speaking individuals, those French-speaking were less likely to have an income in the $50,000-$100,000 range (versus < $20,000) and be part of the Comprehensive cohort.

*Association between language and loss to follow-up*

In Quebec, 839 (9.0%) were LFU with 13.9% among English-speaking, 11.5% among French-speaking and 7.2% among Bilingual individuals (Table 2). Outside Quebec, 3,849 (9.7%)

were LFU with 24.4% among French-speaking, 11.0% among English-speaking and 7.5% among Bilingual individuals. In Quebec, compared to the French-speaking majority, multivariable logistic regression models (Table 3) revealed that LFU risks did not differ among English-speaking minority (OR 1.18, 95% CI 0.67-2.08), but was lower among the Bilingual individuals (0.78, 0.63-0.98). While, outside Quebec, compared to the English-speaking majority, LFU risks were higher in the French-speaking minority (2.33, 1.19-4.55), and not significantly lower in Bilingual individuals (0.85, 0.72-1.02). While, the LFU risk was lower in Bilingual individuals versus the French-speaking minority (0.45, 0.24-0.86). When comparing outside versus in Quebec, LFU risks did not differ among Bilingual individuals (1.11, 0.88-1.41) nor among English-speaking individuals (0.85, 0.49-1.48), but it was higher among French-speaking individuals (2.35, 1.19-4.64).

**Table 3. Association between language and loss to follow-up by province (in Quebec and outside Quebec): Multivariable logistic regression model**

| | LFU versus not LFU N=49,179 |
|---|---|
| **Interaction effect of province and language conversation*** | |
| Outside Quebec Bilingual versus outside Quebec English majority | 0.85 (0.72 - 1.02) |
| Outside Quebec French minority versus outside Quebec English majority | 2.33 (1.19 – 4.55) |
| Outside Quebec Bilingual versus outside Quebec French minority | 0.45 (0.24 - 0.86) |
| Quebec Bilingual versus Quebec French majority | 0.78 (0.63 - 0.98) |
| Quebec English minority versus Quebec French majority | 1.18 (0.67 - 2.08) |
| Quebec English minority versus Quebec Bilingual | 1.52 (0.86 - 1.18) |
| Outside Quebec French minority versus Quebec French majority | 2.35 (1.19 - 4.64) |
| Outside Quebec Bilingual versus Quebec Bilingual | 1.11 (0.88 - 1.41) |
| Outside Quebec English majority versus Quebec English minority | 0.85 (0.49 - 1.48) |
| Years since arrival to Canada‡ | |
| Non-immigrant | 1 |
| ≤20 years | 1.84 (1.34 - 2.53) |
| >20 years | 0.94 (0.81 - 1.10) |
| Depression (Yes versus No) | 1.27 (1.12 – 1.43) |
| Sex | |
| Male | 1 |
| Female | 0.90 (0.81 – 1.00) |
| Age, years, | |
| 45 - 60 | 1 |
| 61 - 70 | 0.88 (0.78 – 1.00) |
| 71 - 85 | 1.29 (1.13 – 1.46) |
| Total household income | |
| <20,000$ | 1 |
| 20,000-50,000$ | 0.68 (0.57 - 0.81) |
| 50,000-100,000$ | 0.50 (0.42 - 0.60) |

| | |
|---|---|
| >100,000$ | 0.41 (0.33 - 0.50) |
| Education level | |
| < Post-secondary school | 1 |
| Post-secondary degree/diploma | 0.64 (0.57 - 0.72) |
| Setting | |
| Urban | 1 |
| Rural | 1.20 (1.06 - 1.35) |
| Alcohol consumption | |
| Never | 1 |
| About 1-4 times/month | 0.78 (0.67 - 0.89) |
| ≥2 times a week | 0.65 (0.56 - 0.76) |
| Smoking status | |
| Smoker | 1 |
| Former smoker | 0.67 (0.58 – 0.76) |
| Non-smoker | 0.67 (0.59 - 0.76) |
| Nutritional risk (High versus low) | 1.28 (1.15 - 1.42) |
| Cohort type (Comprehensive vs. Tracking) | 0.49 (0.44 – 0.54) |
| Age at arrival in Canada (years old) ‡ | |
| Non-immigrant | 1 |
| ≤22 | 0.85 (0.69 - 1.05) |
| >22 | 1.32 (1.10 - 1.58) |

OR=Odds Ratio; CI=Confidence Interval; LFU= loss to follow-up (withdrawn or did not provide data at 3-year follow-up).

*Language is defined using the language that "you can conduct a conversation with" coded as English-speaking only, French-speaking only or Bilingual. French-speaking individuals: can converse in French with or without any other language but English; English-speaking individuals: can converse in English with or without any other language but French; Bilingual: can converse in English and French with or without any other language. Outside Quebec refers to all Canadian provinces other than Quebec. The model adjusted for all the variables included in Table 1. Sex, age, cohort type, and province were forced in the model.

‡ These results are from a separate model using age at arrival rather than years since arrival in Canada.

Participants who were of female sex, ages 61-70 years (versus 45-60 years), with higher income (versus < $20,000), had higher-education and were part of the Comprehensive cohort had lower LFU risks at three years. Higher LFU risks were found in individuals ages 71-85 years (versus 45-60 years), those who had high nutritional risk and those who never consumed alcohol (Table 3).

*Effect of depressive symptoms on LFU*

Overall, baseline depressive symptoms increased the odds of LFU by 27% (Table 3). In the multivariable logistic regression model evaluating the association between language and LFU, no effect modification by depressive symptoms status was observed (Supplemental Table 2). Specifically, Bilingual (versus English-speaking) was associated with a lower LFU among those with depressive symptoms (0.72, 0.54-0.95) and among those with no depressive symptoms, although the latter result was not statistically significant (0.85, 0.71-1.02). The risks of LFU did not differ between English-speaking and French-speaking individuals with and without depressive symptoms at baseline, respectively. Of note, separate analyses were not conducted by province because of low numbers.

*Effect of immigration status on LFU*

The odds of LFU was 84% higher in immigrants who had lived ≤ 20 years in Canada versus non-immigrant (Table 3). However, this effect was only seen among those with no depressive symptoms at baseline (2.20, 1.58-3.05), but not among those with depressive symptoms (Supplemental Table 2). Models that included the age of immigrants at arrival (instead of time since arrival) showed a non-significant higher LFU risk among those whose age at arrival was > 22 years (versus ≤ 20 years; 1.32 (0.99-1.75); an effect seen only among those with no depressive symptoms at baseline (1.39, 1.14-1.70) (Supplemental Table 3). The association between language and LFU risk was similar in immigrants and non-immigrants (Supplemental Table 3).

## Discussion

In our study, immigrant status, baseline depressive symptoms and language were associated with LFU risk at three years. Overall, relatively recent immigrants (≤ 20 years) had 84% increased odds of LFU compared to non-immigrants and those with depressive symptoms at baseline had 24% increased odds of LFU compared to those without such symptoms. In Quebec and outside Quebec, Bilingual individuals had lower odds of LFU than French-speaking individuals. In addition, while the risk of LFU did not differ between the English-speaking minority versus the French-speaking majority in Quebec, it was higher in the French-speaking minority versus the English-speaking majority outside Quebec. No modifying effects by baseline depressive symptoms and by immigrant status were found on the association between language and LFU.

Bilingualism in our study seem to have a protective effect against LFU when compared to French-speaking in Quebec and outside Quebec. Our results also pointed to a lower LFU risk for the Bilingual group versus the English-speaking group inside and outside Quebec, respectively, although these results did not reach statistical significance. Studies have shown better executive control (cognitive skills, working memory), protection against cognitive decline with aging and coping mechanism against dementia in Bilingual individuals. This may explain at least in part the lower risk of LFU found in Bilingual individuals (404). Differences in results between the Bilingual group versus those who speak only the language of the majority in Quebec (French) and outside Quebec (English), respectively may be due to differences in the population mix and culture (405). Of our study population, 49% (4,547/9329) were Bilingual in Quebec, while only 16% (6429/39850) were Bilingual outside Quebec and of the Bilingual group in Quebec, 10% were immigrant compared to 20% of the Bilingual group outside Quebec. In addition, Bilingual versus French-speakers in Quebec were more likely to be older and male (Supplemental Table 1b), while Bilingual versus English speakers outside Quebec did not differ in terms of age, but were more likely to be female (Supplemental Table 1c). These differences highlight the importance of conducting separate analyses in Quebec and outside Quebec.

Outside Quebec, the French-speaking minority had twice the LFU risk of the English-speaking majority in our study. Although the direction of this risk was the same as that for the

French-speaking majority group (versus Bilingual) inside Quebec, it was twice as high outside vs inside Quebec (OR 2.35; 95% CI 1.19-4.64). Lower SES and education attainment were reported among the French-speaking minority outside Quebec (395, 406). With these disadvantages, social adaptation to an environment where you don't speak the language of the majority can be challenging (104). Language barrier may cause isolation, difficulty in accessing services and health disparity (18, 104). Studies have reported that patients with language barriers were more likely to skip a follow-up medical appointment (407) and less likely to adhere to treatment regimen(408). Challenges arisen from communication barriers may increase the risk of dropping out from prospective studies (409).

Our results also showed that those who had depressive symptoms at baseline had 27% higher risk of LFU than those without these symptoms. Similar to our study, a U.S. prospective study of cardiovascular prevention found that participants with depression at baseline had a higher risk of LFU (392). Our finding is also in agreement with results from other studies showing an increased LFU risk in participants with low self-rated mental health (266) or with anxiety disorders (410). However, contrary to our study, depression and anxiety were not associated with LFU in a longitudinal study conducted in Spain (2005-2006) (411). Differences between the results of the Spanish study and ours may be due to differences in the study population and timing of LFU assessment. The Spanish study included patients 18-75 years old recruited from primary care settings and assessed LFU at 6 and 12 months, while our study included individuals 45-85 years old recruited from the community and assessed LFU at three years. Determinants of LFU may differ between younger and older individuals. Indeed, in the Spanish study, the risk of LFU decreased with age, while in our study individuals over 70 years of age were at higher risk of LFU compared to those 45-60 years old.

Of note, our analyses by baseline depressive symptoms showed an increased risk of LFU in English-speaking versus Bilingual individuals among those with depressive symptoms and pointed to a non-significant increase in the English-speaking group among those with no such symptoms. Other comparisons between language groups among those with depressive symptoms and those without such symptoms were not significant. No other study has looked at the effect modification of depressive symptoms on the association between language and LFU.

In our study, immigrants who resided $\leq$ 20 years in Canada had an 84% higher odd of LFU compared to non-immigrant. Immigrants experience acculturative stressors on the individual level

(financial constraints, language barriers), societal level (discrimination, unequal job opportunities), and organizational level (system navigation) that are more pronounced in the earlier years of arrival (24, 339). These factors in addition to time commitment and frequent returns to birth country may increase the risk of LFU in immigrants (402, 409). Our analyses though showed similar associations between the language groups and LFU in both immigrants and non-immigrants pointing toward a language rather than an immigrant status effect.

Our study showed that baseline socio-demographic variables (income, educational attainment, sex, and age) were associated with LFU. Similar to our study, lower education attainment and lower income were associated with higher risks of LFU in other studies (266, 389, 390, 411). Also, as in our study, male participants were more likely to dropout from other longitudinal studies compared to female participants (266). Moreover, as previously mentioned, older age in our study was associated with an increased risk of LFU. Results on the association between age and LFU have varied in the literature depending on the population studied and the duration of follow-up. Contrary to our study, two studies from Europe including individuals ≥ 20 years old (389), or 18-75 years old (411), found decreased risks of LFU with increasing age, while, another study from Europe found an increased risk of LFU in those 18 to 40 years old and, similar to our study, a lower risk in those 51 to 70 years old as compared with those 71 to 80 years old (266).

Our study also showed that lifestyle choices (nutritional risk, alcohol consumption and smoking) were associated with LFU. Current smokers were found to be at higher risks of LFU in our study as well as in other published studies (266, 389, 390). Also, in our study, those who reported that they did not consume alcohol in the past year had higher risks of LFU compared with those who reported moderate and heavier use of alcohol, respectively, while moderate and heavier users of alcohol had similar risks. Contrary to our study, other studies found a higher risk of LFU with high alcohol consumption (389, 390). The higher risk of LFU found in our study among those who reported not having consumed alcohol in the past year was not completely understood. A possible explanation is the heterogeneity of this group that may have included those who abstain from alcohol use because of medical reasons, those with previous self or family history of alcohol addiction as well as abstainers for religious beliefs who are mostly foreign born (412). We did not have information on the reasons for abstinence from drinking in our study. Although, we have adjusted for immigrant status and some medical comorbidity in the analyses, residual bias may

have remained. In addition, several studies have found alcohol consumption to be underreported and have attributed this mainly to social desirability and poor recall which may also explain at least in part our results (413, 414). In one US longitudinal survey, more than half of those who reported never having had a drink of any alcoholic beverage had reported drinking in previous surveys (412). Moreover, differences in categorization of heavy drinking defined as > 42 drinks per week in one study (390) and ≥ 2 drinks per week in our study may explain the lack of difference between moderate (1-4 times/month) and heavier drinkers (≥ 2 drinks/week) in our study. We could not study separately the group with higher frequency of drinking in our study because of sample size. Our study has also found a higher risk of LFU with those with higher nutritional risk. However, we did not find another study that looked at this factor in association with LFU.

Our study did not find a significant impact of chronic diseases on LFU. However, other studies have reported such differences (264, 397-399), where living with serious health conditions such as cancer, arthritis, hypertension led to LFU. Different population mix and longer follow-up in the published studies may explain at least in part these differences (264).

Strengths of our study include the use of the carefully designed population-based and high quality-data of the CLSA database. Our study has also some limitations. CLSA did not provide the participant's reason for withdrawal or not providing data at three years. Therefore, we were unable to determine if some of the language minority groups migrated between provinces or if immigrants had returned to their country of origin which may have affected their LFU. However, a comparison of the participant's province at baseline and follow-up showed that no one from those who provided data at three years had changed province during the study period. Also, data of the Tracking and Comprehensive databases were collected through different means, namely telephone and on-site and home-visits, respectively. Indeed, our results showed that the Comprehensive cohort participants had a lower risk of LFU than the Tracking cohort participants. This might be due to differences in the data collection methods of the two cohorts. One study found that respondents to a telephone interview were less cooperative and engaged, more suspicious of the interview process, and more likely to express dissatisfaction with the length of interview compared to respondent to a face-to-face interview (401). However, in a meta-analysis including 143 longitudinal cohort studies, Teague and colleagues (2008) showed that studies that used site and home visits had a 7% increased rate of participant retention that was borderline significant (p-

value 0.07) compared to studies that used other methods of data collection (401). Nonetheless, we adjusted for Cohort type in all of our analyses.

Whether our findings can be generalized to minorities in other Bilingual countries is unclear, nonetheless it will be important for researchers to consider language, immigrant status and depressive symptoms in their attempt to mitigate the risk of LFU in their prospective cohort study. In the meta-analysis by Teague and colleagues, strategies that aim to reduce the participant burden (i.e. flexibility in data collection methods and time flexibility) were the most effective method to help reduce LFU (402).

In conclusion, LFU was not random in the CLSA cohort. Language, immigrant status and depressive symptoms at baseline were important LFU determinant with no effect modification by depressive symptoms and immigrant status on the association between language and LFU. Studies may need to consider these factors when imputing missing data for those lost to follow-up and to adjust or stratify their analyses accordingly. They also need to consider retention strategies that target individuals with these factors.

## Chapter VII: Discussion of the findings

The overall goal of my thesis was to examine the physical and mental health disparities in immigrants and non-immigrants, and to evaluate whether data completeness differed between immigrants and non-immigrants.

***In manuscript 1***, I used the CLSA Comprehensive cohort baseline and 18-month MCQ data to study the risk of undiagnosed depression at baseline, persistent depressive symptoms and seeking mental health care for these symptoms at 18 months in immigrants and non-immigrants. I hypothesized that immigrants were at higher risk of undiagnosed depression than Canadian-born non-immigrants. I also hypothesized that depressive symptoms were more likely to persist at 18 months in immigrants compared to non-immigrants and that immigrants were less likely to seek mental health care for their depressive symptoms.

I used a retrospective cohort design and included those who reported not having been diagnosed with any mood disorder in the previous 12 months and not using any current treatment for depression. Among immigrants, 12.2% had undiagnosed depression at baseline compared to 10.6% of non-immigrants. I showed that female immigrants were 50% more likely to have undiagnosed depression compared to female non-immigrants, while I did not detect any such difference in males. Immigrants who had resided for less than 20 years in Canada and those who had resided for > 40 years had higher risks of undiagnosed depression than non-immigrants. However, I did not find any differences in persistent depressive symptoms and in seeking mental health care for these symptoms at 18 months between immigrants and non-immigrants.

My study was the first to assess the risk of undiagnosed depressive symptoms in immigrants in Canada. Raina and colleagues (2021) showed that 16.4% of the overall CLSA participants self-reported depression at baseline (415). *My finding implies that about 40% of Canadians with depression may be undiagnosed.*

The higher risk of undiagnosed depression found in my study in female immigrants vs female non-immigrants, may be explained by the higher unemployment rate, lower income and lower social

support in female immigrants (130, 154, 416, 417). These socio-economic stressors added to the acculturative stressors in females may have increased their emotional problems and risk of depressive symptoms to an extend that was not explained by these factors alone. Straiton and colleagues (2014) evaluated the interactions between age and sex on the risk of depression among immigrants in Australia and found that the risk of depression increased with age among females, but it decreased with age among males (418). Other studies looking at sex and immigrant status found a lower risk of mental health among immigrant males compared to immigrant females (32, 309). Although male immigrants also face socio-economic and acculturative stressors albeit to a different extent than female immigrants (130, 416), it is not clear why in my study I did not find a difference in undiagnosed depression between male immigrants and male non-immigrants.

Income seems to be also an important predictor of depression in immigrants and income varied between sexes (Figure 1). Low income (< 20,000$) was associated with undiagnosed depression and persistent depressive symptoms in my study. Using the 2000-2001 CCHS (ages 18 to 74 years) data, Smith and colleagues (2007) reported the highest rate of depression among low-income, non-recent immigrant females (419). *The sex inequities in mental health found in my study between female and male immigrants deserves further investigation to understand the needs of the growing population of immigrants. Immigrants made up one fifth of the Canadian population in 2011 and are expected to reach 27% of that population by 2031 (153).*

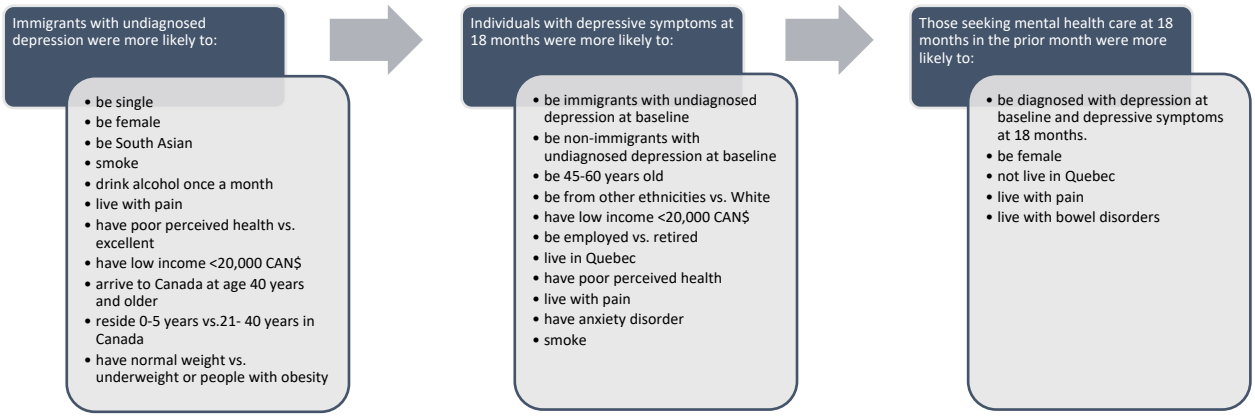
In my study, immigrants who resided in Canada for < 20 years or for > 40 years, but not those who resided between 20 and 40 years were at increased risk of undiagnosed depression than the Canadian-born individuals. The first 20 years of residence are particularly stressful for immigrants. The acculturation and integration challenges that immigrants face during this period may explain their increased risk of depression (122, 143, 325, 326). However, as reported by Elshahat and colleagues (2021) (46), results from the literature regarding the mental health status of immigrants compared to non-immigrants during this period are inconsistent with studies reporting lower risks in immigrants (29-38) and others reporting higher risks (8, 39) or no difference in risks (32) compared to non-immigrants. Of note, the time-period considered in the definition of 'recent immigrants' has varied widely between studies from less than 5 years to less than 20 years (46). Differences in the ethnic composition of the population of immigrants studied, parental nativity,

contextual factors, and the pre-immigration experience lived by immigrants may have contributed to the discrepancy in the results (35, 204, 420). In addition, most studies defined depression based on self-report of physician diagnoses or health services utilization for mental health, while others used an instrument for their assessment. Self-report of physician diagnoses may underestimate greatly the true prevalence of depression in immigrants because of reluctance to seek timely mental health services and fear of stigma (24, 55, 56).

Over time, psychological acculturation of immigrants improves when coupled with resilience and coping mechanisms with culturally-defined lifestyle norms and adapted behaviors to the host country (11, 174). This may explain the similar risks of undiagnosed depression found in immigrants who have resided in Canada for 20 to 40 years and Canadian non-immigrants. However, it was not clear from my data why the risk of depression increased in immigrants after 40 years of living in Canada compared to that of the Canadian-born individuals. Increased feeling of loneliness and reminiscing over one's home-country and decline of health with old age may perhaps explain some of this result (8, 200, 421).

I also showed that age > 40 years at immigration was also a predictor of undiagnosed depression. Similarly, in a U.S. based-study, Latino immigrants were at higher risk of psychiatric disorders when immigrating after the age of 35 years (333). In a U.S. cross-sectional study in Chinese community-dwelling individuals ages 60 years and older, Guo and colleagues (2019) compared the levels of depression by age of immigration to the U.S. (203). They found that immigrating in later life (ages 65 and above) was associated with more depressive symptoms (203). Increased depressive symptoms in this group was partially attributed to their low income, lack of access to health care, poor physical health, and weak social relations (203). Functional limitations also contributed to their higher levels of depressive symptoms. Wilmoth and colleagues (2003) also showed that living alone affected negatively the mental health of older immigrants (8). *Understanding the increased risk of depressive symptoms among older immigrants deserves to be further explored in future studies to inform clinical practice and guide public health policy concerned with the health and wellbeing of an aging population.*

Figure 1. Summary of the results of manuscript 1




When evaluating the longitudinal relationship between the risk of undiagnosed depression at baseline and having persistent depressive symptoms at 18 months, I did not find differences between immigrants and non-immigrants. Similar results were found by Salami and colleagues (2017) when comparing Canadian-born individuals to long-term immigrants using data from the CHMS (33). Of note, immigrants and non-immigrants in my study who had undiagnosed depression at baseline were 5-times more likely to have depressive symptoms at 18 months compared to their counterparts without undiagnosed depression. *This highlights the recurrent nature of depression (422), and the importance of screening and treating depression early on to limit the risk of persistent depressive symptoms. No other study has looked at depressive symptoms over time in immigrants.*

I also did not find any difference in seeking professional mental health care for depressive symptoms between immigrants and non-immigrants. Similar results were found in a multi-centre cross-sectional study in Germany (49). In that study, Gaigl and colleagues (2022) reported no difference in utilization of mental health treatments and met/unmet mental healthcare needs when comparing immigrants to non-immigrants (49). Studies have also reported that immigrants receive untimely diagnosis and treatment of mental illnesses because of their lower access to primary care and lower referral for mental health care (50, 258, 259). Indeed, in a recent Canadian study, Kurdyak and colleagues (2022) found that immigrants were 20% more likely to have their first contact with mental healthcare services through an emergency department visit compared to non-immigrants (50). It is important to note that, in my study, the rates of seeking mental health care

were very low in both immigrants and non-immigrants. *Improved access and availability of family physicians may minimize mental health adversities that can develop into more severe symptoms* (423-425).

***In manuscript 2,*** I used the CLSA Comprehensive cohort baseline and 3-year follow-up data to study in immigrants and non-immigrants: 1) the risk of depressive symptoms at the 3-year follow-up assessment among those with diabetes and no depression at baseline; and the risk of diabetes at the 3-year follow-up assessment among those with depression and no diabetes at baseline. I hypothesized that the association between depression and diabetes was bidirectional in immigrants and in non-immigrants. I also hypothesized that immigrants with diabetes were at higher risk of developing depression compared to non-immigrants with diabetes and immigrant with depression were at higher risk of developing diabetes compared to non-immigrants with depression. Building on the results of my first study, I hypothesized that factors such as sex, age at immigration and time of residence would be important predictors of these relationships.

Using multivariable logistic regression models, I found an overall (in immigrants and non-immigrants combined) bidirectional relationship between diabetes and depression. Study individuals with (vs without) depression at baseline had a 43% higher odds to develop diabetes during the 3-year follow-up. Depression status at baseline was associated with a 39% increased odds of new onset diabetes in non-immigrants and a 60% increased odds in immigrants. Individuals with (vs without) baseline diabetes had 18% higher odds of depression at three years. Diabetes was associated with a 27% increased odds of depression in non-immigrants, but not in immigrants.

A higher risk of diabetes was also reported among individuals with (vs without) depression by other studies (93, 358, 426). Similar results were found in a meta-analysis conducted by Zhuang and colleagues (2017), where individuals with (vs without) depression at baseline had 34% higher risk of new onset diabetes (240), although the studies included in the meta-analysis used various ascertainment methods for depression including patient chart reviews (427, 428), clinical interview (429-431), and physician diagnosis and medication use based on administrative databases (432, 433) and had various immigrant ethnicity mix (434) and follow-up periods. When evaluating

differences by immigrant status, results showed that depression was associated with 60% increased odds of new onset diabetes in immigrants and 39% increased odds of new onset diabetes in non-immigrants.

My study was the first study to assess depression as a risk factor for diabetes in immigrants. As stated in Misra and Ganda (2007), the psychological stress of settlement could lead to unhealthy eating habits (229), defined as "nutrition transition" which, compounded with a more sedentary lifestyle increases the risk of weight gain in immigrants (230, 231). Deterioration in lifestyle habits can also lead to insulin resistance, and thus higher risk of developing diabetes and other chronic diseases (128, 373, 374). Graham and colleagues (2021) linked CCHS (2000-2003) and NPHS (1996) data with Ontario health administrative data to look at the risk of diabetes among adults with (vs without) depression over up to 20 years follow-up period (435). They found that adults with depression-related weight gain, depression-related weight loss and no depression-related weight change had, respectively 70% , 62% and 39% increase in the risk of type 2 diabetes compared to those with no depression. These results suggest that depression may increase the risk of diabetes through pathways other than weight change alone. The study did not examine the risk of depression-related diabetes in immigrants.

Antidepressant use has also been associated with weight gain and obesity and may also increase the risk of diabetes (348, 349, 436). It is not clear if antidepressant use differed between immigrants and non-immigrants in my study, as information about medication use was not available. Also, some immigrants, in particular those from South Asia, the Caribbean, sub-Saharan Africa and Latin America (71, 77, 83) may experience a higher burden of diabetes because of genetic predisposition. Unfortunately, I was unable to evaluate the risk of diabetes by immigrants' ethnicity because of small sample size.

I also showed that individuals (immigrants and non-immigrants combined) with (vs without) baseline diabetes had 18% higher odds of depression at three years. However, while diabetes at baseline was associated with 27% increased odds of depression among non-immigrants, a non-significant increase by 12% was observed among immigrants.

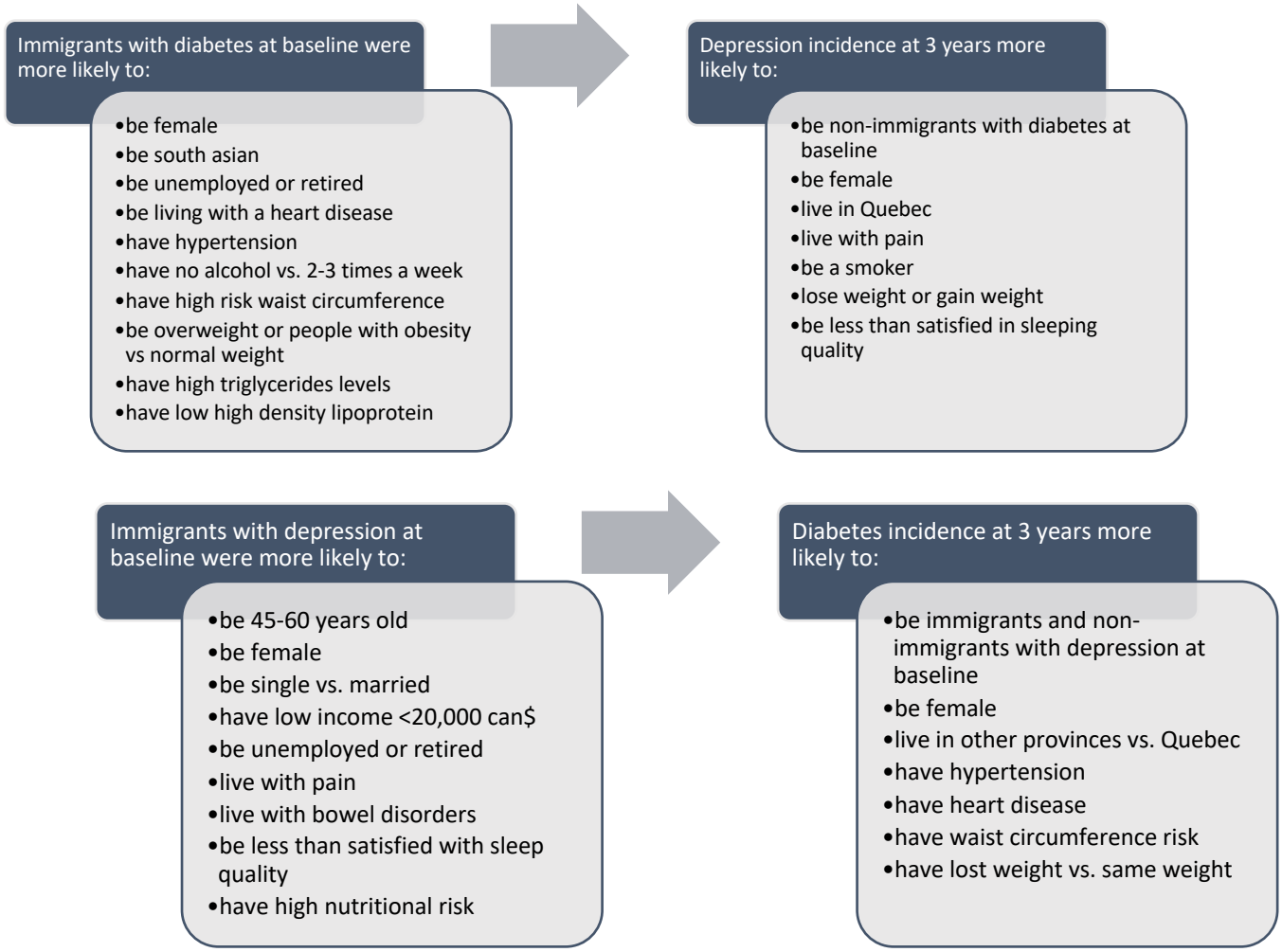
Stress associated with poor control of blood sugar, strict dieting, physical exercise requirements and poor sleep quality may increase the risk of depression in individuals with (vs without) diabetes. Chronic stress may cause hyper-activation of the hypothalamic-pituitary-adrenal axis and increase in cortical volume and has been proposed as a possible clinical pathway between diabetes and depression (93, 437). Nutrition can also play a role in the onset, severity and duration of depression (438-441). In a recent review, Ljunberg and colleagues (2020) showed that avoiding processed food, intake of food supplements (e.g magnesium, folic acid, fatty acids), and fish consumption can decrease the risk of depression (442). Higher risks of depression have also reported with macrovascular and microvascular complications of diabetes (238, 433).

Four U.S. studies assessed the risk of depressive symptoms in immigrants with vs without diabetes (81, 89, 241, 242). However, only one of these studies was of some relevance to mine (89). However, that study used a cross-sectional design and included only immigrants. The other three studies presented important differences in the study population (only female (89), only Korean American (241), or only 75 years or older (242)), comparator group (Mexican females (81)), outcome (mortality and disability (242) or study design (cross-sectional (81, 89, 241, 242)) and analyses (only descriptive (241)) compared to my study. The first study evaluated the risk of depressive symptoms among Mexican American females with diabetes compared to their counterparts in Mexico (81). The second study was only descriptive and reported the proportion of those with depressive symptoms among Korean Americans with diabetes compared to their U.S.-born counterparts (241), and the third study looked at the risk of mortality and disability associated with having both diabetes and depression among Mexican Americans 75 years of age and older (242). The fourth study was conducted by Morales and colleagues (2021) among U.S. immigrants only (89). The authors used a cross-sectional design and reported a 64% increase in the odds of depressive symptoms among immigrants with (vs without) diabetes. They also reported that being female, poor, and from specific regions in Latin America increased the risks of having both diabetes and depression.

My study evaluated the association between diabetes and depression using a longitudinal study design and ascertained depression using a validated instrument. However, it was not clear from my study if the lack of association between diabetes at baseline and depression at the 3-year follow-

up in immigrants was due to my small sample size or to a true absence of an association. *Future studies should further investigate the dual relationship between diabetes and depression among immigrants compared to non-immigrants to further understand the variations of these risks by time of residence, sex, age at immigration and ethnicity.*

Figure 4. Summary of the results of manuscript 2




***In my third manuscript***, I used the CLSA Comprehensive and Tracking cohorts' baseline and three-year follow-up data to study the risk of loss to follow-up and its determinants in immigrants and non-immigrants. I hypothesized that those who are immigrants, those with depressive

symptoms and those who cannot converse in the official language were more likely to drop out of the CLSA at three years.

Using multivariable logistic regression models, I found that immigrant status, baseline depressive symptoms and language were associated with an increased risk of loss to follow-up at three years. I showed that individuals (immigrants and non-immigrants) with depressive symptoms at baseline had 24% increased odds of loss to follow-up compared to those without such symptoms. I also found that relatively recent immigrants (≤ 20 years) had 84% increased odds of loss to follow-up compared to non-immigrants. I showed that immigrants who landed in Canada at 22 years of age or above had a 32% higher odds of loss to follow-up. I also found that Bilingual individuals (who can converse in English and French) were less likely to be lost to follow-up than French individuals (who can converse in French, but not English). In addition, while the risk of loss to follow-up did not differ between the English minority vs the French majority in Quebec, it was higher in the French minority vs the English majority outside Quebec.

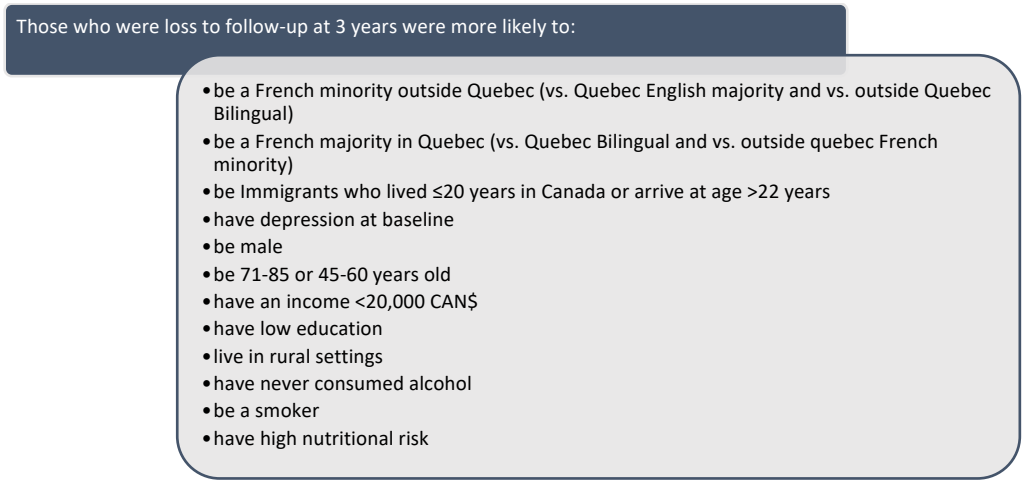
In my study, depressive symptoms at baseline were associated with increased risk of loss to follow-up at three years. This finding is concordant with the results of several other studies looking at the association between high levels of psychological distress and loss to follow-up, particularly in high-risk populations including immigrants (266, 392, 410).

I also showed that the risk of loss to follow-up was higher in relatively recent immigrants and immigrants who arrived in Canada at or above the age of 22 years. Higher acculturative stressors and lack of social cohesion that immigrants experience in the earlier years following arrival may explain these results (339, 340). These factors in addition to time commitment, not wanting to share private information, and frequent returns to birth country may increase the risk of loss to follow-up in immigrants (402, 409). A recent mixed-methods study in Mexican immigrants to the U.S. found that Mexican women who migrated at an older age (above 37 years old) were at higher risk of depressive symptoms compared to those who migrated at a younger age (443). Similarly, a Swedish mixed-methods study found that psychological distress in immigrants increased with age at immigration relative to native-born individuals (340). In my study, I was unable to examine the combined effect of depressive symptoms and age at immigration on the risk of loss to follow-up

because of sample size limitations. In a U.S. prospective study of cardiovascular prevention, Bambs and colleagues (2013) found that participants with depression had a higher risk of dropping out from their study (392).

In my study, I also sought to determine whether the association between language and loss to follow-up was explained by immigrant status. However, my analyses showed similar associations between the language groups considered and loss to follow-up in both immigrants and non-immigrants indicating a possible language barrier in both groups. Bilingualism in my study had a protective effect against loss to follow-up when compared to French in Quebec and outside Quebec. Linguistic adaptation to an environment where you don't speak the language can be challenging (54, 57, 58, 104, 134). Lack of language acquisition can create a sense of isolation from the majority of the population, disadvantage at getting better pay at their employment, and difficulty in accessing the health care system leading to health disparities (444). In my study, I was not able to assess the risk among those who speak a language other than English or French at home because of the small sample size. Nearly 6.6 million people (one fifth of the Canadian population) speak a language other than French or English at home and 30% of these individuals do not speak either official language at home (445).

Figure 6. Summary of the results of manuscript 3




A key advantage of cohort studies over other observational study designs is that repeated measures data facilitate temporal causal inference between exposures and outcomes (446). When certain participants drop out from cohorts non-randomly, loss of information may bias the results. In my

study, participants who were of female sex, ages 61 to 70 years (vs 45 to 60 years), with higher income (vs < $20,000), had higher-education and were part of the Comprehensive cohort were less likely to be lost to follow-up at three years. Higher odds for loss to follow-up were found in individuals ages 71 to 85 years (vs 45 to 60 years), those who had high nutritional risk and those who never consumed alcohol. Similar risk factors for non-random loss to follow-up were found in other studies (403). In a U.S. longitudinal study (2006 to 2008), Jacobsen and colleagues (2021) found that those who were more likely to drop out of their study were older, male, have lower cognitive test scores, lower functional ability, no physical activity, low social network and worse self-rated health (403). In a 4-year U.S. longitudinal study, Bambs and colleagues (2013) found that black race, younger age, male sex, no health insurance and obesity were independently associated with higher risks of loss to follow-up whereas having a spouse/partner participating in the study was associated with lower risks (392). In a meta-analysis including 143 longitudinal cohort studies, Teague and colleagues (2008) showed that strategies that aim to reduce the participant burden (i.e. flexibility in data collection methods) might be the most effective method in retaining participants (402). *Several retention strategies have been employed by CLSA including conducting an interim data collection to maintain contact (269). However, the risk of loss to follow-up remains elevated for the mentioned groups despite these efforts. Researchers need to be aware of the impact of loss-to-follow-up on their findings and appropriately adjust for its risk factors in the analyses.*

## Strengths and limitations

Strengths of my studies include the high quality of the population based, national CLSA data I used. The longitudinal study design and the availability of anthropomorphic measurements and blood assessments (vitamin D and iron deficiency, lipid profile, lean and fat mass) in addition to the of lifestyle, socio-demographic, socio-economic and clinical data in my study were strengths; these data are usually unavailable in other studies and most other studies were cross-sectional.

My studies have also some limitations. First, the CLSA participants had to complete the questionnaires in either English or French and were relatively physically and cognitively able to participate on their own. Also, the CLSA excludes full-time members of the Canadian Armed Forces, and institutionalized persons (270). Therefore, my results may not apply to Canadian immigrants who cannot converse in either English or French and those who were in the armed forces or institutionalized at the time of the study. Second, in my study, I was not able to account for ethnic subgroup differences, immigrant category (i.e. investment (economic), refugee, independent, family reunion) and family structure were not captured in my analyses (91-93, 240). Third, my study population was 45 years of age or older and the majority of my immigrant population had lived in Canada for 40 years and more (63%). This precluded the study of younger as well as more recent immigrants. Fourth, immigrants' mental health may also be affected by their settlement and integration experiences in Canada, including the location where they settle and health systems where they seek care. However, these distinctions cannot be determined from the data I used. Fifth, CLSA was based on voluntary participation and participants may be different from non-participants (384). Also, reasons for lack of participation and withdrawal from the study were not provided. Therefore, participation bias cannot be ruled out in my study (334) despite accounting for the analytical weights generated by CLSA and adjusting for the variables associated with loss to follow-up in my models.

Sixth, depression symptoms at baseline and 3-year follow-up were assessed using the depression screening tools CES-D and K10. Although the CES-D and K10 tools have been validated and are widely used, self-reported information is prone to measuring errors, recall bias, and information bias (337). In addition, we had access to information on depressive symptoms at two time-points

which may not be sufficient to determine the fluctuating of depressive symptoms over time (447). More frequent observations are necessary to reliably assess the prognosis of late-life depression (448). Diabetes status at three years was also self-reported. Therefore, misclassification in depressive symptoms and in diabetes statuses cannot be ruled out in my study. Nonetheless, misclassification in these outcomes was likely non-differential and would have biased the results toward a lower effect. Seventh, psychosocial variables such as discrimination and resilience were not available for my study but social support and participation in social activities were evaluated. Eighth, the effect of glycemic control on the risk of depression could not be assessed in my study (382). Nineth, in my third study, I analysed the data of Tracking and Comprehensive cohorts combined. These cohorts were collected through different means with the Tracking cohort using telephone interview and the Comprehensive cohort using in-person home- and site-interview and on-site clinical assessments and blood sample collection. However, I have adjusted for cohort type in all my models.

## Future directions

My thesis has provided evidence to support the existence of physical and mental health disparities between immigrants and non-immigrants in Canada. Personal-, societal- and system- level factors that contribute to health inequities in the immigrant population are not clearly understood and their inter-relation is complex and not clearly delineated. Qualitative studies among immigrants from various origins, socio-economic status, age, sex and time of residence are needed to understand the complex interplay of contextual barriers and opportunities with individual life circumstances and behaviour. This will further uncover the root causes of health inequities in immigrants and inform the planning and implementation of appropriate health promotion and intervention programs.

My studies have revealed that the risk of depression, diabetes and loss to follow-up in immigrants change by time of residence after adjusting for age and sex. It is important to continue assessing these risks and the implication of help-seeking factors, cross-cultural differences, social inequalities and availability of services over time using the CLSA data as they accumulate (24). This will provide further understanding of the trajectory of the mental health status and its synergic relationship with diabetes in immigrants and will inform public health interventions that aim to improve the physical and mental wellbeing of the aging population.

In my studies, the increase in the adjusted risk of depressive symptoms with time of residence exceeding 40 years, with the exception of 20 to 40 years of residence, was surprizing. Deterioration in mental wellbeing among long-term established immigrants beyond aging is concerning and needs to be further investigated in future studies to inform public health policy aiming to improve the population healthy aging.

Access to mental health services is also a complex notion that needs further investigation. Future studies should evaluate the utilization of mental health resources in immigrants accounting for ethnic origins and personal beliefs. Ethnic disparity has been reported in Canada and elsewhere among immigrants.

Longitudinal studies, particularly those conducted in older adults, lose participants over time. It is crucial to recognize that drop out from longitudinal studies may not be random and may bias the

study results if not accounted for in the analyses. My thesis showed that immigrant status, language and depressive symptoms are predictors of loss to follow-up. Future studies trying to impute missing information in longitudinal cohorts, should not consider missingness to be completely at random or noninformative (449); immigrant status, depressive symptoms and language should be considered and adjusted for in the models. Also, my findings provide an opportunity for researchers to identify the characteristics of those likely to drop out of the study before the 3-year follow-up assessment. Researchers may want to consider oversampling individuals with these characteristics to allow to study of these individuals over time.

## Chapter VIII: Conclusion and summary

In this Ph.D. thesis, among middle-aged and older adults, I found immigrants to be at higher risk of undiagnosed depression compared to non-immigrants. However, immigrants and non-immigrants who experienced depression at baseline were at similar risks for persistent depressive symptoms at 18 months and sought mental health care for their symptoms at similar low rates. I also found that immigrants and non-immigrants with depression at baseline were at higher risk of developing diabetes within a 3-year period than their peers without depression. In addition, non-immigrants with diabetes at baseline were at a higher risk of having depression at three years than non-immigrants without diabetes. However, this later association was not conclusive for immigrants. I also showed that loss to follow-up was non-random in the data I used and was higher among immigrants, those with depressive symptoms at baseline and those who were not bilingual.

The growing number of immigrants in Canada and in other Western countries and the changes in the pre- and post-immigration experiences mandate continued research regarding the mental and physical health disparities between immigrants and non-immigrants. The Healthy Immigrant Effect and Years Since Immigration Effect (i.e. decreasing health with longer time of residence) did not apply to the risk of depression in my study. Immigrants seemed to be at higher risks in the first 20 years of residence with their risk decreasing between 20 and 40 years of residence, to increase again after 40 years. Additional longitudinal studies are needed to understand the trajectory of mental health in immigrants.

Immigration is vital for Canada's future economic growth. My findings are important to policy makers to help direct their prevention strategies toward those at higher risks in order to optimize healthcare resources while improving the wellbeing of the population. Based on my 3-year population-based cohort studies, time of residence, age at immigration, sex, income, and language proficiency are important determinants that should be considered. In summary, my findings have implications on the design and conduct of future studies and on the development of prevention strategies that could reduce the risks of depression, diabetes and loss to follow-up in immigrants as well as in non-immigrants.

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## Appendix A: Manuscript 1 supplemental

Table A: Risk factors associated with having undiagnosed depression at baseline

| | Non-immigrant (N= 18,620) | Immigrant (N= 4,382) |
|---|---|---|
| | Adjusted OR (95% CI) | |
| **Predisposing characteristics** | | |
| Age, years, | | |
| 45 - 60 | 1 | 1 |
| 61 - 70 | 0.88 (0.74 - 1.05) | 0.87 (0.60 - 1.27) |
| 71 - 85 | 1.04 (0.85 - 1.28) | 0.85 (0.55 - 1.29) |
| Sex | | |
| Male | 1 | 1 |
| Female | 1.29 (1.13 - 1.47) | 2.06 (1.56 - 2.71) |
| Marital status | | |
| Single | 1 | 1 |
| Married | 0.78 (0.63 - 0.97) | 0.47 (0.30 - 0.75) |
| Widowed/divorced/separated | 0.97 (0.78 - 1.21) | 0.54 (0.33 - 0.89) |
| Cultural and racial background | | |
| White | | 1 |
| Black | 0.74 (0.20 - 2.75) | 0.76 (0.39 - 1.47) |
| South Asian | 3.63 (0.87 - 15.15) | 3.33 (2.09 - 5.29) |
| Chinese | 1.53 (0.53 - 4.45) | 0.89 (0.43 - 1.84) |
| First Nations | 1.17 (0.49 - 2.78) | - |
| Other | 1.23 (0.55 - 2.75) | 1.28 (0.79 - 2.08) |
| Length of residence in Canada (years) | | |
| 0-5 | - | 1 |
| 6-10 | | 0.56 (0.20 - 1.54) |
| 11-20 | - | 0.46 (0.18 - 1.18) |
| 21-40 | - | 0.34 (0.14 - 0.82) |

| | | |
|---|---|---|
| > 40 | - | 0.44 (0.18 - 1.07) |
| **Enabling resources** | | |
| Total household income Can $ | | |
| < 20,000 | 1 | 1 |
| 20,000- less than 50,000 | 0.90 (0.69 - 1.19) | 0.44 (0.24 - 0.81) |
| 50,000- less than 100,000 | 0.72 (0.54 - 0.95) | 0.36 (0.19 - 0.67) |
| ≥ 100,000 | 0.54 (0.40 - 0.74) | 0.28 (0.14 - 0.56) |
| Working status | | |
| Employed | 1 | |
| Unemployed | 1.67 (1.28 - 2.19) | 1.34 (0.75 - 2.40) |
| Retired | 0.86 (0.72 - 1.02) | 0.97 (0.68 - 1.38) |
| Province | | |
| Quebec | 1 | 1 |
| British Columbia | 0.80 (0.65 - 0.98) | 0.87 (0.59 - 1.29) |
| Ontario | 0.94 (0.78 - 1.15) | 0.89 (0.59 - 1.32) |
| Other | 1.02 (0.87 - 1.21) | 0.95 (0.65 - 1.40) |
| **Needs-related factors** | | |
| Perceived Health | | |
| Poor | 1 | 1 |
| Fair | 0.89 (0.51 - 1.56) | 1.57 (0.55 - 4.44) |
| Good | 0.43 (0.25 - 0.75) | 0.72 (0.27 - 1.93) |
| Very Good | 0.26 (0.15 - 0.44) | 0.44 (0.16 - 1.19) |
| Excellent | 0.16 (0.09 - 0.28) | 0.22 (0.08 - 0.63) |
| Medical Conditions (Yes vs. No) | | |
| Living with pain | 1.71 (1.50 - 1.95) | 1.71 (1.32 - 2.21) |
| Bowel disorders | 1.32 (1.08 - 1.60) | 1.29 (0.78 - 2.14) |
| Arthritis | 0.60 (0.42 - 0.86) | 1.24 (0.60 - 2.55) |
| Anxiety disorder | 2.63 (2.04 - 3.39) | 1.46 (0.74 - 2.89) |
| **Personal health choices** | | |
| Alcohol consumption | | |
| Never | 1 | 1 |

| | | |
|---|---|---|
| About once a month | 0.80 (0.64 - 1.00) | 1.60 (1.02 - 2.52) |
| 2-4 times a month | 0.80 (0.65 - 0.99) | 1.53 (0.95 - 2.45) |
| > 2 times a week | 0.83 (0.68 - 1.01) | 1.23 (0.78 - 1.95) |
| Smoking status | | |
| Smoker | 1 | 1 |
| Former smoker | 0.92 (0.75 - 1.13) | 0.58 (0.37 - 0.92) |
| Non-smoker | 0.83 (0.66 - 1.04) | 0.44 (0.27 - 0.71) |
| Weight classification [a] | | |
| Normal weight | 1 | 1 |
| Underweight | 0.87 (0.46 - 1.64) | 0.10 (0.01 - 0.97) |
| Overweight | 0.87 (0.74 - 1.01) | 0.86 (0.64 - 1.17) |
| Obese | 0.81 (0.69 - 0.95) | 0.68 (0.48 - 0.97) |
| Physical activity | | |
| Never or once a year | 1 | 1 |
| Once a month | 0.94 (0.79 - 1.13) | 1.03 (0.70 - 1.52) |
| Once a week | 0.75 (0.64 - 0.87) | 0.97 (0.71 - 1.32) |
| Once a day | 0.68 (0.53 - 0.88) | 0.95 (0.57 - 1.56) |

OR= Odds Ratio; CI= Confidence Intervals

The multivariate logistic regression model adjusted for all baseline characteristics included in Table 1. Variables that were not significant on the multivariate level were removed from the table. Sex, age and province were forced in the model.

[a] Based on Body Mass Index international classification for adults aged 18 and over.

Table B: Association of immigrant status with undiagnosed depression at baseline [a]: Multivariate logistic regression models (N= 23,002)

| | Adjusted OR (95% CI) |
|---|---|
| Female immigrant versus female non-immigrant | 1.50 (1.25 - 1.80) |
| Female immigrant versus male immigrant | 1.85 (1.45 - 2.37) |
| Female non-immigrant versus male non-immigrant | 1.30 (1.14 - 1.47) |
| Male immigrant versus male non-immigrant | 1.05 (0.86 - 1.28) |
| **Predisposing characteristics** | |
| Age, y | |
| 45-60 | 1 |
| 61-70 | 0.76 (0.66 - 0.86) |
| 71-85 | 0.84 (0.73 - 0.96) |
| Marital Status | |
| Single | 1 |
| Married | 0.75 (0.62 - 0.91) |
| Widowed/Divorced/Separated | 0.92 (0.75 - 1.11) |
| **Enabling resources** | |
| Total household income Can $ | |
| < 20,000 | 1 |
| 20,000- less than 50,000 | 0.72 (0.57 - 0.92) |
| 50,000- less than 100,000 | 0.58 (0.45 - 0.74) |
| ≥ 100,000 | 0.43 (0.33 - 0.56) |
| Province | |
| Quebec | 1 |
| British Columbia | 0.86 (0.72 - 1.02) |
| Ontario | 0.95 (0.80 - 1.23) |
| Other | 1.04 (0.90 - 1.21) |
| **Needs-related factors** | |
| Perceived Health | |

| | |
|---|---|
| Poor | 1 |
| Fair | 0.95 (0.59 - 1.51) |
| Good | 0.47 (0.30 - 0.75) |
| Very Good | 0.27 (0.17 - 0.43) |
| Excellent | 0.16 (0.10 - 0.26) |
| Medical Conditions (Yes vs. No) | |
| Living with pain | 1.64 (1.47 - 1.84) |
| Bowel Disorders | 1.29 (1.08 - 1.54) |
| Anxiety disorder | 2.34 (1.85 - 2.95) |
| **Personal health choices** | |
| Smoking status | |
| Smoker | 1 |
| Former smoker | 0.85 (0.70 - 1.02) |
| Non-smoker | 0.75 (0.61 - 0.91) |
| Weight classification [b] | |
| Normal weight | 1 |
| Underweight | 0.70 (0.38 - 1.29) |
| Overweight | 0.85 (0.75 - 0.97) |
| Obese | 0.78 (0.68 - 0.90) |
| Physical activity | |
| Never or once a year | 1 |
| Once a month | 0.93 (0.79 - 1.09) |
| Once a week | 0.75 (0.66 - 0.86) |
| Once a day | 0.70 (0.56 - 0.87) |

OR= Odds ratio, CI= Confidence Interval;

[a] used CES-D-10 ≥ 10

[b] Based on Body Mass Index international classification for adults ≥ 18 years of age.

Table C: Association of immigrant status with undiagnosed depression at baseline: Multivariate logistic regression models (N= 23,002)

| | Undiagnosed depression [a] versus not | |
|---|---|---|
| | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
| Model 1 [b] | | |
| Age at arrival in Canada (years old) | | |
| Non-immigrant | 1 | 1 |
| 0-5 | 1.07 (0.82 - 1.40) | 1.20 (0.89 - 1.60) |
| 6-17 | 1.09 (0.84 - 1.41) | 1.21 (0.89 - 1.63) |
| 18-22 | 1.32 (1.00 - 1.74) | 1.18 (0.86 - 1.63) |
| 22-40 | 1.16 (0.98 - 1.37) | 1.17 (0.95 - 1.42) |
| > 40 | 2.21 (1.64 - 2.97) | 2.02 (1.43 - 2.86) |
| Model 2 [b] | | |
| Length of residence in Canada (years) | | |
| Non-immigrant | 1 | 1 |
| 0-5 | 4.47 (2.45 - 8.17) | 3.30 (1.59 - 6.85) |
| 6-10 | 1.79 (1.10 - 2.91) | 1.84 (1.08 - 3.11) |
| 11-20 | 1.39 (0.98 - 1.96) | 1.53 (1.02 - 2.29) |
| 21-40 | 1.10 (0.88 - 1.36) | 1.03 (0.80 - 1.33) |
| > 40 | 1.15 (1.00 - 1.33) | 1.21 (1.02 - 1.43) |

OR= Odds Ratio; CI= Confidence Interval;

[a] Undiagnosed depression is assessed using CES-D-10 score ≥ 10 at baseline;

[b] Both Model 1 and 2 included age, sex, province, income, marital status, smoking, perceived health, anxiety disorder, living with pain, bowel disorders, weight, physical activity. Note that variables that were not significant on the univariate level were removed from the model.

Table D: Associations of immigrant status with and without undiagnosed depression at baseline with depressive symptoms at 18 months: Multivariate logistic regression models (N= 23,002)

| | Adjusted OR (95% CI) |
|---|---|
| Interaction effect of Immigrant status and UD at baseline | |
| Immigrant with UD versus immigrant without UD | 5.37 (4.04 - 7.14) |
| Immigrant with UD versus non-immigrant with UD | 1.10 (0.84 - 1.45) |
| Immigrant without UD versus non-immigrant without UD | 1.15 (0.95 - 1.39) |
| Non-immigrant with UD versus non-immigrant without UD | 5.59 (4.79 - 6.52) |
| Interaction effect of sex and UD at baseline [a] | |
| Female with UD versus female without UD | 5.10 (4.29 - 6.06) |
| Female with UD versus male with UD | 1.06 (0.84 - 1.33) |
| Female without UD versus male without UD | 1.25 (1.09 - 1.44) |
| Male with UD versus male without UD | 6.02 (4.90 - 7.41) |
| **Predisposing characteristics** | |
| Age, years, | |
| 45 - 60 | 1 |
| 61 - 70 | 0.77 (0.66 - 0.91) |
| 71 - 85 | 0.77 (0.64 - 0.93) |
| Cultural and racial background | |
| White | 1 |
| Black | 0.91 (0.50 - 1.64) |
| South Asian | 1.49 (0.91 - 2.44) |
| Chinese | 1.62 (0.91 - 2.89) |
| Other | 1.57 (1.10 - 2.25) |
| **Enabling resources** | |
| Total household income Can $ | |
| < 20,000 | 1 |
| 20,000- less than 50,000 | 0.68 (0.53 - 0.88) |
| 50,000- less than 100,000 | 0.60 (0.46 - 0.77) |
| ≥ 100,000 | 0.44 (0.34 - 0.58) |

| | |
|---|---|
| Working status | |
| Employed | 1 |
| Unemployed | 1.16 (0.88 - 1.52) |
| Retired | 0.69 (0.59 - 0.81) |
| Province | |
| Quebec | 1 |
| British Columbia | 0.51 (0.42-0.61) |
| Ontario | 0.55 (0.46-0.65) |
| Other | 0.52 (0.45-0.60) |
| **Needs-related factors** | |
| Perceived Health | |
| Poor | 1 |
| Fair | 0.64 (0.39 - 1.06) |
| Good | 0.47 (0.29 - 0.77) |
| Very Good | 0.30 (0.18 - 0.48) |
| Excellent | 0.21 (0.13 - 0.36) |
| Medical Conditions | |
| Living with pain | 1.59 (1.41 - 1.80) |
| Anxiety disorder | 2.21 (1.73 - 2.84) |
| **Personal health choices** | |
| Smoking status | |
| Smoker | 1 |
| Former smoker | 0.69 (0.57 - 0.83) |
| Non-smoker | 0.69 (0.57 - 0.83) |

OR= Odds Ratio; CI=Confidence Interval; UD= Undiagnosed Depression

[a] The model adjusted for all the variables included in Table 1.

Table E: Full model of the associations of immigrant status, baseline undiagnosed depression and depressive symptoms at 18 months with seeing a physician for these feelings in the prior month: Multivariate logistic regression models (N= 16,519)

| | Seeing a mental health care professional at 18 months | |
|---|---|---|
| | Unadjusted OR (95% CI) | Adjusted OR (95% CI) |
| Immigrant versus non-immigrant | 1.02 (0.83 - 1.23) | 0.95 (0.77 - 1.17) |
| UD with DS versus UD with no DS | 3.01 (2.16 - 4.18) | 3.11 (2.20 - 4.37) |
| UD with DS versus no UD with DS | 0.93 (0.70 - 1.23) | 0.97 (0.72 - 1.30) |
| No UD with DS versus no UD with no DS | 4.88 (3.99 - 5.97) | 5.05 (4.09 - 6.24) |
| UD with no DS versus no UD and no DS | 1.75 (1.34 - 2.28) | 1.58 (1.19 - 2.09) |
| **Predisposing characteristics** | | |
| Age, y | | |
| 45 - 60 | 1 | 1 |
| 61 - 70 | 0.85 (0.71 - 1.01) | 0.88 (0.73 - 1.05) |
| 71 - 85 | 1.05 (0.88 - 1.25) | 0.98 (0.81 - 1.18) |
| Sex | | |
| Male | 1 | 1 |
| Female | 1.35 (1.16 - 1.58) | 1.22 (1.03 - 1.43) |
| **Enabling resources** | | |
| Province | | |
| Quebec | 1 | 1 |
| British Columbia | 1.21 (0.94 - 1.57) | 1.54 (1.18 - 2.02) |
| Ontario | 1.50 (1.17 - 1.93) | 1.82 (1.41 - 2.35) |
| Other | 1.68 (1.35 - 2.10) | 1.97 (1.56 - 2.48) |
| **Needs-related factors** | | |
| Medical Conditions | | |
| Living with pain | 1.72 (1.48 - 2.01) | 1.38 (1.17 - 1.63) |
| Bowel disorders | 1.81 (1.43 - 2.29) | 1.45 (1.12 - 1.88) |

CES-D= Center for Epidemiological Studies Depression 10 Scale; K10= Kessler Psychological Distress Scale 10; UD= Undiagnosed Depression, defined by CES-D score ≥ 10 at baseline; DS= Important Depressive Symptoms, defined by K10 score ≥ 19 at 18 months; OR= Odds Ratio; CI= Confidence Interval;

Note that variables that were not significant on the univariate level were removed from the table. Sex, age and province were forced in the model.

## Appendix B: Manuscript 2 supplemental

Appendix 1. Description of baseline characteristics described for Cohort 1 and 2

Baseline characteristics included sociodemographic and socioeconomic factors: sex, age (45-60, 61-70 and 71-85 years), immigration status (yes/no), ethnic/racial background (White, Black, South Asian, Chinese and Other), marital status (widowed, divorced or separated), language most spoken at home (French, English and other), household income (Can$, < 20,000; 20,000-50,000; 50,000-100,000 and > 100,000), employment status (employed, unemployed and completely or partly retired), education (post-secondary, secondary, < secondary), province (Ontario, British Columbia, Quebec, and other provinces [Alberta, Manitoba, Nova Scotia, Prince Edward Island, Newfoundland and Labrador, Saskatchewan]), and place of residence (urban or rural based on postal code areas with rural having < 10,000 people) (313, 450); common medical conditions: living with pain, history of cancer, arthritis, bowel disorders (Crohn's disease, ulcerative colitis or irritable bowel syndrome), myocardial infarction, heart disease, and hypertension; perceived health ("poor", "fair", "good", "very good" or "excellent"), sleep satisfaction (satisfied/very satisfied, neutral, dissatisfied/very dissatisfied); personal health choices: alcohol consumption (no, occasional or regular) in the past year, smoking status (current, former and never); anthropomorphic measurements: World Health Organization (WHO) classification for adults aged ≥ 18 years of body mass index (BMI) (314) and of waist circumference (WC) risk status (high risk, men: ≥ 102 cm women: ≥88cm) (451); Nutritional risk scored using AB SCREEN$^{TM}$ II (high and low risk) (400); and weight change ("Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"); laboratory test results: vitamin D deficiency (< 30 nmol/L), iron deficiency (Ferritin ≥ 30 µg/L), high

triglycerides (≥ 1.7 mmol/L), high low density lipoprotein (LDL, ≥ 5 mmol/L), high non high density lipoprotein (nHDL, ≥ 4.3 nmol/L); DEXA-measured [total lean mass (without bone, $kg/m^2$) and total fat mass ($kg/m^2$)].

Table 1: Baseline characteristics of Cohort 1 study individuals with and without baseline diabetes by immigration status

| | Immigrant (N= 3,766) | | | Non-immigrant (N= 16,957) | | |
|---|---|---|---|---|---|---|
| | Diabetes ( N= 616) | No Diabetes ( N= 3,150) | OR (95% CI)* (N= 3,766) | Diabetes ( N= 2,639) | No Diabetes ( N= 14,318) | OR (95% CI)* * (N= 16,957) |
| | N (%) | | | N (%) | | |
| Age, years | | | | | | |
| 45-60 | 141 (22.9) | 1,173 (37.2) | 1 | 893 (33.8) | 7,050 (49.2) | 1 |
| 61-70 | 236 (38.3) | 1,050 (33.3) | 1.30 (0.88 - 1.92) | 969 (36.7) | 4,224 (29.5) | 1.06 (0.91 -1.25) |
| 71-85 | 239 (38.8) | 927 (29.4) | 1.24 (0.79 - 1.96) | 777 (29.4) | 3,044 (21.3) | 0.91 (0.75 - 1.11) |
| Sex | | | | | | |
| Male | 408 (66.2) | 1,743 (55.3) | 1 | 1,551 (58.8) | 7,167 (50.1) | 1 |
| Female | 208 (33.8) | 1,407 (44.7) | 0.70 (0.53 - 0.92) | 1,088 (41.2) | 7,151 (49.9) | 0.74 (0.65 - 0.84) |
| Marital status | | | | | | |
| Single | 27 (4.4) | 149 (4.7) | | 234 (8.9) | 1,176 (8.2) | |
| Married | 455 (73.9) | 2,405 (76.3) | - | 1,834 (69.5) | 10,407 (72.7) | - |
| Widowed/divorced/separated | 134 (21.8) | 595 (18.9) | - | 571 (21.6) | 2,731 (19.1) | - |
| Language most spoken at home | | | | | | |
| French | 31 (5.0) | 205 (6.5) | | 541 (20.5) | 3,171 (22.1) | |
| English | 492 (79.9) | 2,597 (82.4) | - | 2,092 (79.3) | 11,114 (77.6) | - |
| Other | 55 (8.9) | 254 (8.1) | | 3 (0.1) | 17 (0.1) | |
| Years since arrival to Canada | | | | | | |
| < 20 | 42 (3.4) | 396 (12.6) | - | - | - | - |
| 20-40 | 162 (26.2) | 781 (20.7) | - | - | - | - |
| > 40 | 412 (66.9) | 1,973 (61.6) | - | - | - | - |
| Ethnic/racial background | | | | | | |
| White | 464 (75.3) | 2,640 (83.8) | 1 | 2,596 (98.4) | 14,166 (98.9) | |
| Black | 36 (5.8) | 89 (2.8) | 1.82 (0.91 - 3.62) | 8 (0.3) | 19 (0.1) | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| South Asian | 50 (8.1) | 122 (3.9) | 2.31 (1.33 - 4.03) | 0 (0.0) | 6 (0.0) | - |
| Chinese | 24 (3.9) | 107 (3.4) | 1.53 (0.82 - 2.84) | 8 (0.3) | 37 (0.3) | - |
| Other | 42 (6.8) | 188 (6.0) | 1.22 (0.69 - 2.17) | 25 (0.9) | 80 (0.6) | - |
| Total household income (CAD$) | | | | | | |
| < 20,000 | 29 (4.7) | 82 (2.6) | | 140 (5.3) | 432 (3.0) | 1 |
| 20,000-50,000 | 141 (22.9) | 589 (18.7) | - | 641 (24.3) | 2,435 (17.0) | 0.94 (0.69 - 1.29) |
| 50,000-100,000 | 245 (39.8) | 1,076 (34.2) | - | 927 (35.1) | 4,786 (33.4) | 0.75 (0.55 - 1.02) |
| > 100,000 | 163 (26.5) | 1,180 (37.5) | - | 779 (29.5) | 5,855 (40.9) | 0.65 (0.47 - 0.89) |
| Working status | | | | | | |
| Employed | 158 (25.6) | 1,333 (42.3) | 1 | 826 (31.3) | 6,368 (44.5) | 1 |
| Unemployed | 29 (4.7) | 111 (3.5) | 2.65 (1.38 - 5.09) | 72 (2.7) | 468 (3.3) | 0.76 (0.52 - 1.10) |
| Retired | 429 (69.6) | 1,699 (53.9) | 1.45 (1.01 - 2.09) | 1,732 (65.6) | 7,453 (52.1) | 1.17 (1.00 - 1.37) |
| Education level | | | | | | |
| < Secondary school | 20 (3.2) | 77 (2.4) | | 188 (7.1) | 590 (4.1) | |
| Secondary school | 51 (8.3) | 195 (6.2) | - | 316 (12.0) | 1,275 (8.9) | - |
| Post-secondary degree/diploma | 541 (87.8) | 2,870 (91.1) | - | 2,134 (80.9) | 12,436 (86.9) | - |
| Place of residence*** | | | | | | |
| Rural | 58 (9.4) | 310 (9.8) | | 365 (13.8) | 1,849 (12.9) | 1 |
| Urban | 551 (89.4) | 2,799 (88.9) | - | 2,239 (84.8) | 12,303 (85.9) | 0.75 (0.63 - 0.90) |
| Province | | | | | | |
| Quebec | 65 (10.6) | 365 (11.6) | 1 | 536 (20.3) | 3,199 (22.3) | 1 |
| British Columbia | 189 (30.7) | 996 (31.6) | 1.24 (0.78 - 1.97) | 538 (20.4) | 2,736 (19.1) | 1.81 (1.48 - 2.21) |
| Ontario | 169 (27.4) | 869 (27.6) | 0.80 (0.50 - 1.29) | 551 (20.9) | 2,920 (20.4) | 1.34 (1.10 - 1.62) |
| Other**** | 193 (31.3) | 920 (29.2) | 0.84 (0.52 - 1.34) | 1,014 (38.4) | 5,463 (38.2) | 1.21 (1.02 - 1.44) |
| Perceived health | | | | | | |
| Poor | 13 (2.1) | 16 (0.5) | | 31 (1.2) | 39 (0.3) | |
| Fair | 54 (8.8) | 106 (3.4) | - | 264 (10.0) | 518 (3.6) | - |
| Good | 253 (41.1) | 806 (25.6) | - | 1,075 (40.7) | 3,321 (23.2) | - |
| Very good | 211 (34.3) | 1,384 (43.9) | - | 972 (36.8) | 6,708 (46.9) | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Excellent | 84 (13.6) | 836 (26.5) | - | 295 (11.2) | 3,724 (26.0) | - |
| Medical conditions | | | | | | |
| Living with pain | 226 (36.7) | 944 (30.0) | - | 1,055 (40.0) | 4,260 (29.8) | 1.20 (1.06 - 1.37) |
| Bowel disorders | 41 (6.7) | 227 (7.2) | - | 224 (8.5) | 1,135 (7.9) | - |
| Arthritis | 16 (2.6) | 83 (2.6) | - | 109 (4.1) | 355 (2.5) | - |
| Heart disease | 370 (60.1) | 1,007 (32.0) | 1.93 (1.39 - 2.67) | 1,552 (58.8) | 4,353 (30.4) | 1.85 (1.59 - 2.14) |
| Kidney disease | 36 (5.8) | 66 (2.1) | - | 111 (4.2) | 292 (2.0) | - |
| Stroke | 11 (1.8) | 36 (1.1) | - | 65 (2.5) | 157 (1.1) | - |
| Cancer | 95 (15.4) | 475 (15.1) | - | 465 (17.6) | 2,005 (14.0) | - |
| Hypertension | 355 (57.6) | 1,081 (34.3) | 1.56 (1.13 - 2.15) | 1,530 (58.0) | 4,851 (33.9) | 1.96 (1.68 - 2.28) |
| Anxiety disorder | 17 (2.8) | 109 (3.5) | - | 137 (5.2) | 606 (4.2) | - |
| Alcohol consumption | | | | | | |
| Never | 92 (14.9) | 309 (9.8) | 1 | 340 (12.9) | 1,209 (8.4) | 1 |
| About once a month | 141 (22.9) | 514 (16.3) | 0.93 (0.62 - 1.38) | 608 (23.0) | 2,255 (15.7) | 0.98 (0.79 - 1.23) |
| 2-4 times a month | 115 (18.7) | 576 (18.3) | 0.66 (0.42 - 1.05) | 588 (22.3) | 3,160 (22.1) | 0.77 (0.62 - 0.95) |
| > 2 times a week | 239 (38.8) | 1,641 (52.1) | 0.52 (0.35 - 0.77) | 1,031 (39.1) | 7,433 (51.9) | 0.60 (0.49 - 0.73) |
| Smoking status | | | | | | |
| Non smoker | 297 (48.2) | 1,691 (53.7) | | 1,088 (41.2) | 7,184 (50.2) | |
| Former smoker | 275 (44.6) | 1,291 (41.0) | - | 1,348 (51.1) | 6,029 (42.1) | - |
| Smoker | 44 (7.1) | 168 (5.3) | - | 203 (7.7) | 1,105 (7.7) | - |
| Sleep quality | | | | | | |
| Satisfied or very satisfied | 373 (60.6) | 2,014 (63.9) | | 1,615 (61.2) | 9,114 (63.7) | |
| Neutral | 116 (18.8) | 513 (16.3) | - | 388 (14.7) | 2,158 (15.1) | - |
| Dissatisfied or very dissatisfied | 127 (20.6) | 617 (19.6) | - | 635 (24.1) | 3,038 (21.2) | - |
| Nutritional risk status | | | | | | |
| Low risk | 394 (64.0) | 2,256 (71.6) | | 1,577 (59.8) | 10,128 (70.7) | 1 |
| High risk | 201 (32.6) | 796 (25.3) | - | 1,008 (38.2) | 3,919 (27.4) | 1.20 (1.04 - 1.38) |
| Waist circumference risk status | | | | | | |
| Low risk | 263 (42.7) | 2,128 (67.6) | 1 | 908 (34.4) | 8,966 (62.6) | 1 |

| | | | | | | |
|---|---|---|---|---|---|---|
| High risk | 353 (57.3) | 1,022 (32.4) | 1.66 (1.18 - 2.34) | 1,731 (65.6) | 5,352 (37.4) | 2.19 (1.92 - 2.50) |
| Weight classification † | | | | | | |
| Normal weight | 112 (18.2) | 1,193 (37.9) | 1 | 383 (14.5) | 4,827 (33.7) | |
| Overweight | 248 (40.3) | 1,312 (41.7) | 1.50 (1.04 – 2.16) | 967 (36.6) | 6,086 (42.5) | - |
| Obese | 253 (41.1) | 638 (20.3) | 2.10 (1.33 - 3.32) | 1,277 (48.4) | 3,365 (23.5) | - |
| Weight change ‡ | | | | | | |
| Same weight | 401 (65.1) | 2,152 (68.3) | | 1,574 (59.6) | 9,693 (67.7) | 1 |
| Gained weight | 69 (11.2) | 447 (14.2) | - | 385 (14.6) | 2,012 (14.1) | 1.18 (0.98 - 1.41) |
| Lost weight | 132 (21.4) | 494 (15.7) | - | 646 (24.5) | 2,439 (17.0) | 1.32 (1.13 - 1.55) |
| Laboratory tests | | | | | | |
| Vitamin D deficiency | | | | | | |
| ≥ 30 nmol/L | 522 (84.7) | 2,719 (86.3) | | 2,314 (87.7) | 12,807 (89.4) | 1 |
| < 30 nmol/L | 30 (4.9) | 91 (2.9) | - | 81 (3.1) | 247 (1.7) | 1.55 (1.08 – 1.22) |
| Iron deficiency | | | | | | |
| No | 492 (79.9) | 2,607 (82.8) | | 2,180 (82.6) | 11,978 (83.7) | |
| Yes | 46 (7.5) | 159 (5.0) | - | 147 (5.6) | 878 (6.1) | - |
| Triglycerides | | | | | | |
| < 1.7 mmol/L | 281 (45.6) | 1,808 (57.4) | 1 | 1,107 (41.9) | 8,090 (56.5) | 1 |
| ≥ 1.7 mmol/L | 271 (44.0) | 1,004 (31.9) | 1.55 (1.17 - 2.04) | 1,288 (48.8) | 4,965 (34.7) | 1.52 (1.34 - 1.73) |
| Low density lipoprotein | | | | | | |
| < 5 mmol/L | 518 (84.1) | 2,715 (86.2) | | 2,271 (86.1) | 12,621 (88.1) | |
| ≥ 5 mmol/L | 8 (1.3) | 61 (1.9) | - | 16 (0.6) | 219 (1.5) | - |
| Non high density lipoprotein | | | | | | |
| < 4.3 nmol/L | 448 (72.7) | 2,026 (64.3) | 1 | 1,891 (71.7) | 9,529 (66.6) | 1 |
| ≥ 4.3 nmol/L | 78 (12.7) | 750 (23.8) | 0.49 (0.35 - 0.69) | 396 (15.0) | 3,311 (23.1) | 0.61 (0.52 - 0.72) |
| | Mean (SD) | | | Mean (SD) | | |
| Total lean mass (kg/m$^2$) | 18.7 (2.7) | 17.3 (2.6) | - | 18.9 (2.9) | 17.7 (2.8) | - |
| Total fat mass (kg/m$^2$) | 10.2 (3.7) | 8.7 (3.1) | - | 11.0 (4.0) | 9.3 (3.5) | - |

SD= Standard Deviation

Diabetes at baseline was assessed with Hb1Ac ≥ 7% and/or a positive answer to “Has a doctor ever told you that you have diabetes, borderline diabetes or that your blood sugar is higher?”

* Odds ratio derived from a multivariable logistic regression model comparing baseline characteristics of immigrant with diabetes versus immigrants without diabetes.

** Odds ratio derived from a multivariable logistic regression model comparing baseline characteristics of non-immigrant with diabetes versus non-immigrants without diabetes.

*** The place of residence classification (urban or rural) was derived by CLSA based on Statistics Canada's Postal Code Conversion File where rural areas were those with a total population of less than 10,000.

****Other provinces are Alberta, Manitoba, Nova Scotia, Prince Edward Island, Labrador and Saskatchewan

† Based on Body Mass Index international classification for adults ≥ 18 years of age.

‡ Weight change was defined by the question "Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"

Table 2: Sensitivity analysis of the association between baseline self-reported diabetes and depression at three years: Multivariable logistic regression models

| | Cohort 1: Depression incidence N= 20,695 |
|---|---|
| | Adjusted OR (95% CI) |
| Diabetes* (Yes vs. no) | 1.26 (1.09 - 1.46) |
| **Interaction effect of immigrant status and diabetes at baseline** | |
| Immigrant with diabetes versus immigrant without diabetes | 1.14 (0.82 - 1.60) |
| Immigrant with diabetes versus non-immigrant with diabetes | 1.03 (0.74 - 1.44) |
| Immigrant without diabetes versus non-immigrant without diabetes | 1.16 (0.98 - 1.36) |
| Non-immigrant with diabetes versus non-immigrant without diabetes | 1.28 (1.09 - 1.51) |
| Sex | |
| Male | 1 |
| Female | 1.65 (1.47 - 1.85) |
| Age, years, | |
| 45 - 60 | 1 |
| 61 - 70 | 0.94 (0.82– 1.07) |
| 71 - 85 | 1.30 (1.13 - 1.48) |
| Province | |
| Quebec | 1 |
| British Columbia | 0.68 (0.58 - 0.81) |
| Ontario | 0.65 (0.55 - 0.77) |
| Other | 0.78 (0.67 – 0.90) |
| Medical conditions (Yes vs. no) | |
| Living with pain | 1.54 (1.56 – 1.97) |
| Bowel disorders | 1.75 (1.56 – 1.97) |

| | |
|---|---|
| Smoking status | |
| Smoker | 1 |
| Former smoker | 0.51 (0.42 - 0.62) |
| Non-smoker | 0.46 (0.38 - 0.55) |
| Weight change † | |
| Same weight | 1 |
| Gained weight | 1.31 (1.12 - 1.52) |
| Lost weight | 1.30 (1.12 - 1.51) |
| Sleep quality | |
| Satisfied or very satisfied | 1 |
| Neutral | 1.28 (1.10 - 1.50) |
| Dissatisfied or very dissatisfied | 1.86 (1.63 – 2.11) |

OR= Odds Ratio; CI= Confidence Interval;

* The model adjusted for all the variables included in Table 1. Sex, age and immigration status were forced in the model. The variables that were not significant (p-value > 0.5), which inclusion did not affect the Bayesian Information Criterion and did not modify the effect of the main exposure variable by more than 10% were removed. Diabetes at baseline is assessed with a positive answer to “Has a doctor ever told you that you have diabetes, borderline diabetes or that your blood sugar is higher?” At 3-year follow-up, depression is defined using CES-D-10 score ≥ 10 or currently taking medication for depression for cohort1.

† Weight change is defined by the question "Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"

Table 3: Association between baseline diabetes and three-year depression incidence (Cohort 1) and between baseline depression and three-year diabetes incidence (Cohort 2)*: Multivariable logistic regression models

| | Cohort 1: Depression incidence N= 20,723 | Cohort 2: Diabetes incidence N= 22,041 |
|---|---|---|
| | Adjusted OR (95% CI) | |
| Diabetes* (Yes vs. no) | 1.18 (1.01 - 1.37) | NA |
| Depression*(Yes vs. no) | NA | 1.43 (1.21 - 1.68) |
| **Interaction effect of immigrant status and diabetes at baseline** | | |
| Immigrant with Diabetes versus immigrant with No Diabetes | 1.12 (0.80 - 1.56) | - |
| Immigrant with Diabetes versus non-immigrant with Diabetes | 1.01 (0.72 - 1.41) | - |
| Immigrant with No Diabetes versus non-immigrant with No Diabetes | 1.15 (0.98 - 1.35) | - |
| Non-immigrant with Diabetes versus non-immigrant with No Diabetes | 1.27 (1.08 - 1.49) | - |
| **Interaction effect of immigrant status and depression at baseline** | | |
| Immigrant with Depression versus immigrant with No Depression | - | 1.60 (1.08 - 2.37) |
| Immigrant with Depression versus non-immigrant with Depression | - | 1.10 (0.76 - 1.58) |
| Immigrant with No Depression versus non-immigrant with No Depression | - | 0.96 (0.76 - 1.21) |
| Non-immigrant with Depression versus non-immigrant with No Depression | - | 1.39 (1.16 - 1.68) |
| Sex | | |
| Male | 1 | 1 |
| Female | 1.55 (1.38 - 1.75) | 0.81 (0.70 - 0.94) |
| Age, years, | | |
| 45 - 60 | 1 | 1 |
| 61 - 70 | 0.86 (0.75– 0.98) | 0.93 (0.79 - 1.10) |
| 71 - 85 | 1.08 (0.93 - 1.26) | 0.76 (0.62 - 0.94) |
| Province | | |
| Quebec | 1 | 1 |
| British Columbia | 0.75 (0.63 - 0.90) | 1.09 (0.88 - 1.37) |
| Ontario | 0.73 (0.61 - 0.87) | 0.85 (0.68 - 1.05) |
| Other | 0.86 (0.74 - 1.01) | 0.68 (0.56 - 0.84) |
| Medical conditions (Yes vs. no) | | |

| | | |
|---|---|---|
| Hypertension | - | 1.34 (1.12 - 1.60) |
| Living with pain | 1.74 (1.54 – 1.96) | - |
| Heart disease | - | 1.40 (1.17 - 1.68) |
| Smoking status | | |
| Smoker | 1 | |
| Former smoker | 0.53 (0.44 - 0.65) | - |
| Non-smoker | 0.49 (0.40 - 0.60) | - |
| Waist circumference risk (Yes vs. no) | - | 2.50 (2.13 - 2.92) |
| Weight change† | | |
| Same weight | 1 | 1 |
| Gained weight | 1.30 (1.11 - 1.53) | 1.22 (1.01 - 1.49) |
| Lost weight | 1.30 (1.12 - 1.51) | 1.34 (1.11 - 1.61) |
| Sleep quality | | |
| Satisfied or very satisfied | 1 | |
| Neutral | 1.31 (1.11 - 1.54) | - |
| Dissatisfied or very dissatisfied | 1.90 (1.66 - 2.18) | - |

OR= Odds Ratio; CI= Confidence Interval;

* The model included all the variables listed in Table 1. Sex, age and immigration status were forced in the model. The variables that were not significant (p-value > 0.5), which inclusion did not affect the Bayesian Information Criterion and did not modify the effect of the main exposure variable by more than 10% were removed. Depression was assessed with Center for Epidemiological Studies Depression 10 Scale, CES-D-10 ≥ 10 and/or currently undergoing treatment for depression. Diabetes at baseline was assessed with Hb1Ac ≥ 7% and/or positive answer to “Has a doctor ever told you that you have diabetes, borderline diabetes or that your blood sugar is higher?” At 3-year follow-up, depression was defined using CES-D-10 score ≥ 10 and/or currently taking medication for depression for Cohort 1. For Cohort 2, 3-year incident diabetes is defined using self-reported diabetes diagnosis.

† Weight change was defined by the question "Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"

Table 4: Baseline characteristics of Cohort 2 study individuals with and without depression by immigration status

| | Immigrant (N= 3,913) | | | Non-immigrant (N= 18,141) | | |
|---|---|---|---|---|---|---|
| | Depression ( N= 762) | No Depression ( N= 3,151) | OR (95% CI)* (N= 3,913) | Depression ( N= 3,797) | No Depression ( N= 14,344) | OR (95% CI)** (N= 18,141) |
| | N (%) | | | N (%) | | |
| Age, y | | | | | | |
| 45-60 | 325 (42.7) | 1,173 (37.2) | 1 | 1,941 (51.1) | 7,053 (49.2) | 1 |
| 61-70 | 235 (30.8) | 1,048 (33.3) | 0.62 (0.46 – 0.84) | 1,087 (28.6) | 4,228 (29.5) | 0.79 (0.70 -0.90) |
| 71-85 | 202 (26.5) | 930 (29.5) | 0.46 (0.32 - 0.66) | 769 (20.3) | 3,063 (21.4) | 0.63 (0.54 - 0.74) |
| Sex | | | | | | |
| Male | 266 (34.9) | 1,741 (55.3) | 1 | 1,351 (35.6) | 7,175 (50.0) | 1 |
| Female | 496 (65.1) | 1,410 (44.7) | 1.87 (1.50 - 2.33) | 2,446 (64.4) | 7,169 (50.0) | 1.53 (1.39 - 1.69) |
| Marital status | | | | | | |
| Single | 68 (8.9) | 149 (4.7) | 1 | 485 (12.8) | 1,178 (8.2) | 1 |
| Married | 465 (61.0) | 2,403 (76.3) | 0.60 (0.41 - 0.88) | 2,223 (58.5) | 10,417 (72.6) | 0.81 (0.69 - 0.95) |
| Widowed/divorced/separated | 227 (29.8) | 598 (19.0) | 0.79 (0.52 - 1.18) | 1,088 (28.7) | 2,745 (19.1) | 1.01 (0.86 - 1.19) |
| Language most spoken at home | | | | | | |
| French | 65 (8.5) | 205 (6.5) | | 925 (24.4) | 3,174 (22.1) | |
| English | 597 (78.3) | 2,598 (82.5) | - | 2,861 (75.3) | 11,137 (77.6) | - |
| Other | 58 (7.6) | 254 (8.1) | | 7 (0.2) | 17 (0.1) | |
| Years since arrival to Canada | | | | | | |
| <20 | 112 (14.7) | 395 (12.5) | - | - | - | - |
| 20-40 | 190 (24.9) | 783 (24.8) | - | - | - | - |
| >40 | 460 (60.4) | 1,973 (62.6) | - | - | - | - |
| Ethnic/racial background | | | | | | |
| White | 629 (82.5) | 2,641 (83.8) | | 3,758 (99.0) | 14,191 (98.9) | |
| Black | 24 (3.1) | 89 (2.8) | - | 8 (0.2) | 19 (0.1) | - |
| South Asian | 36 (4.7) | 122 (3.9) | - | 2 (0.1) | 6 (0.0) | - |
| Chinese | 17 (2.2) | 107 (3.4) | - | 7 (0.2) | 37 (0.3) | - |
| Other | 53 (7.0) | 188 (6.0) | - | 20 (0.5) | 81 (0.6) | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Total household income (CAD$) | | | | | | |
| < 20,000 | 57 (7.5) | 82 (2.6) | 1 | 332 (8.7) | 436 (3.0) | 1 |
| 20,000-50,000 | 208 (27.3) | 591 (18.8) | 0.59 (0.34 - 1.01) | 923 (24.3) | 2,443 (17.0) | 0.74 (0.60 - 0.90) |
| 50,000-100,000 | 246 (32.3) | 1,075 (34.1) | 0.45 (0.26 - 0.79) | 1,217 (32.1) | 4,794 (33.4) | 0.60 (0.49 - 0.74) |
| > 100,000 | 194 (25.5) | 1,180 (37.4) | 0.37 (0.21 - 0.66) | 1,088 (28.7) | 5,854 (40.8) | 0.52 (0.41 - 0.65) |
| Working status | | | | | | |
| Employed | 297 (39.0) | 1,332 (42.3) | 1 | 1,510 (39.8) | 6,373 (44.4) | 1 |
| Unemployed | 71 (9.3) | 111 (3.5) | 2.22 (1.49 - 3.31) | 313 (8.2) | 468 (3.3) | 1.83 (1.50 - 1.24) |
| Retired | 393 (51.6) | 1,701 (54.0) | 1.26 (0.92 - 1.71) | 1,964 (51.7) | 7,474 (52.1) | 1.10 (0.97 - 1.24) |
| Education level | | | | | | |
| < Secondary school | 30 (3.9) | 76 (2.4) | | 260 (6.8) | 595 (4.1) | |
| Secondary school | 64 (8.4) | 196 (6.2) | - | 367 (9.7) | 1,278 (8.9) | - |
| Post-secondary degree/diploma | 664 (87.1) | 2,871 (91.1) | - | 3,166 (83.4) | 12,454 (86.8) | - |
| Place of residence *** | | | | | | |
| Rural | 75 (9.8) | 310 (9.8) | | 453 (11.9) | 1,850 (12.9) | 1 |
| Urban | 674 (88.5) | 2,800 (88.9) | - | 3,293 (86.7) | 12,328 (85.9) | 0.75 (0.63 - 0.90) |
| Province | | | | | | |
| Quebec | 111 (14.6) | 365 (11.6) | 1 | 922 (24.3) | 3,204 (22.3) | 1 |
| British Columbia | 227 (29.8) | 995 (31.6) | 0.84 (0.61 - 1.16) | 665 (17.5) | 2,735 (19.1) | 0.90 (0.78 - 1.05) |
| Ontario | 223 (29.3) | 872 (27.7) | 1.11 (0.80 - 1.54) | 855 (22.5) | 2,921 (20.4) | 1.15 (1.00 - 1.31) |
| Other**** | 201 (26.4) | 919 (29.2) | 0.93 (0.67 - 1.30) | 1,355 (35.7) | 5,484 (38.2) | 0.92 (0.81 - 1.04) |
| Perceived health | | | | | | |
| Poor | 25 (3.3) | 16 (0.5) | | 125 (3.3) | 39 (0.3) | |
| Fair | 115 (15.1) | 108 (3.4) | - | 480 (12.6) | 518 (3.6) | - |
| Good | 280 (36.7) | 807 (25.6) | - | 1,389 (36.6) | 3,331 (23.2) | - |
| Very good | 251 (32.9) | 1,383 (43.9) | - | 1,371 (36.1) | 6,714 (46.8) | - |
| Excellent | 90 (11.8) | 835 (26.5) | - | 431 (11.4) | 3,734 (26.0) | - |
| Medical conditions | | | | | | |
| Living with pain | 366 (48.0) | 945 (30.0) | 1.69 (1.37 - 2.08) | 1,904 (50.1) | 4,267 (29.7) | 1.71 (1.55 - 1.88) |
| Bowel disorders | 105 (13.8) | 227 (7.2) | 1.52 (1.07 - 2.17) | 582 (15.3) | 1,136 (7.9) | 1.61 (1.40 - 1.85) |
| Arthritis | 28 (3.7) | 83 (2.6) | - | 160 (4.2) | 354 (2.5) | - |
| Stroke | 15 (2.0) | 37 (1.2) | - | 67 (1.8) | 157 (1.1) | - |

| | | | | | | |
|---|---|---|---|---|---|---|
| Cancer | 117 (15.4) | 474 (15.0) | - | 573 (15.1) | 2,012 (14.0) | - |
| Hypertension | 283 (37.1) | 1,080 (34.3) | - | 1,457 (38.4) | 4,870 (34.0) | - |
| Anxiety disorder | 119 (15.6) | 109 (3.5) | - | 919 (24.2) | 611 (4.3) | - |
| Alcohol consumption | | | | | | |
| Never | 101 (13.3) | 310 (9.8) | | 528 (13.9) | 1,218 (8.5) | 1 |
| About once a month | 171 (22.4) | 512 (16.2) | - | 756 (19.9) | 2,259 (15.7) | 0.71 (0.60 - 0.84) |
| 2-4 times a month | 150 (19.7) | 574 (18.2) | - | 827 (21.8) | 3,166 (22.1) | 0.71 (0.60 - 0.83) |
| > 2 times a week | 310 (40.7) | 1,645 (52.2) | - | 1,625 (42.8) | 7,436 (51.8) | 0.67 (0.58 - 0.78) |
| Smoking status | | | | | | |
| Non smoker | 377 (49.5) | 1,690 (53.6) | | 1,644 (43.3) | 7,200 (50.2) | |
| Former smoker | 315 (41.3) | 1,293 (41.0) | - | 1,690 (44.5) | 6,040 (42.1) | - |
| Smoker | 70 (9.2) | 168 (5.3) | - | 463 (12.2) | 1,104 (7.7) | - |
| Sleep quality | | | | | | |
| Satisfied or very satisfied | 339 (44.5) | 2,014 (63.9) | 1 | 1,692 (44.6) | 9,133 (63.7) | 1 |
| Neutral | 132 (17.3) | 513 (16.3) | 1.42 (1.06 - 1.89) | 588 (15.5) | 2,162 (15.1) | 1.39 (1.22 - 1.59) |
| Dissatisfied or very dissatisfied | 291 (38.2) | 618 (19.6) | 2.57 (2.04 - 3.24) | 1,512 (39.8) | 3,041 (21.2) | 2.04 (1.84 - 2.26) |
| Nutritional risk status | | | | | | |
| Low risk | 381 (50.0) | 2,256 (71.6) | 1 | 1,772 (46.7) | 10,147 (70.7) | 1 |
| High risk | 356 (46.7) | 797 (25.3) | 1.74 (1.41 - 2.15) | 1,941 (51.1) | 3,924 (27.4) | 2.07 (1.88 - 2.28) |
| Waist circumference risk status | | | | | | |
| Low risk | 475 (62.3) | 2,129 (67.6) | | 2,030 (53.5) | 8,983 (62.6) | 1 |
| High risk | 287 (37.7) | 1,022 (32.4) | - | 1,767 (46.5) | 5,361 (37.4) | 1.09 (0.99 - 1.20) |
| Weight classification † | | | | | | |
| Normal weight | 264 (34.6) | 1,194 (37.9) | | 1,205 (31.7) | 4,838 (33.7) | |
| Overweight | 310 (40.7) | 1,313 (41.7) | - | 1,423 (37.5) | 6,094 (42.5) | - |
| Obese | 184 (24.1) | 637 (20.2) | - | 1,144 (30.1) | 3,372 (23.5) | - |
| Weight change ‡ | | | | | | |
| Same weight | 442 (58.0) | 2,150 (68.2) | | 2,204 (58.0) | 9,707 (67.7) | |
| Gained weight | 157 (20.6) | 449 (14.2) | - | 810 (21.3) | 2,020 (14.1) | - |
| Lost weight | 149 (19.6) | 495 (15.7) | - | 725 (19.1) | 2,442 (17.0) | - |
| Laboratory tests | | | | | | |
| Vitamin D deficiency | | | | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| ≥ 30 nmol/L | 633 (83.1) | 2,721 (86.4) | | 3,309 (87.1) | 12,827 (89.4) | - |
| < 30 nmol/L | 25 (3.3) | 90 (2.9) | - | 89 (2.3) | 247 (1.7) | - |
| Triglycerides | | | | | | |
| < 1.7 mmol/L | 402 (52.8) | 1,807 (57.3) | | 1,951 (51.4) | 8,101 (56.5) | |
| ≥ 1.7 mmol/L | 256 (33.6) | 1,006 (31.9) | - | 1,448 (38.1) | 4,974 (34.7) | - |
| Low density lipoprotein | | | | | | |
| < 5 mmol/L | 632 (82.9) | 2,715 (86.2) | | 3,253 (85.7) | 12,641 (88.1) | |
| ≥ 5 mmol/L | 17 (2.2) | 62 (2.0) | - | 75 (2.0) | 219 (1.5) | - |
| Non high density lipoprotein | | | | | | |
| < 4.3 nmol/L | 474 (62.2) | 2,026 (64.3) | | 2,377 (62.6) | 9,550 (66.6) | |
| ≥ 4.3 nmol/L | 175 (23.0) | 751 (23.8) | - | 951 (25.0) | 3,310 (23.1) | - |
| | Mean (SD) | | | Mean (SD) | | |
| Total lean mass (kg/m$^2$) | 16.9 (2.8) | 17.3 (2.6) | - | 17.1 (2.9) | 17.4 (2.8) | - |
| Total fat mass (kg/m$^2$) | 9.8 (3.6) | 8.7 (3.1) | - | 10.4 (4.0) | 9.3 (3.5) | - |

SD= Standard Deviation

Depression was assessed with Center for Epidemiological Studies Depression 10 Scale, CES-D-10 ≥ 10 and/or currently undergoing treatment for depression.

* Odds ratio derived from a multivariable logistic regression model comparing baseline characteristics of immigrant with depression versus immigrants without depression.

** Odds ratio derived from a multivariable logistic regression model comparing baseline characteristics of non-immigrant with depression versus non-immigrants without depression.

*** The place of residence classification (urban or rural) was derived by CLSA based on Statistics Canada's Postal Code Conversion File where rural areas were those with a total population of less than 10,000.

**** Other provinces are Alberta, Manitoba, Nova Scotia, Prince Edward Island, Labrador and Saskatchewan

† Based on Body Mass Index international classification for adults ≥ 18 years of age.

‡ Weight change is defined by the question "Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"

Table 5: Sensitivity analysis of the association between baseline diabetes and depression at three years: missing baseline data were imputed using multiple imputation

| | Cohort 1: Depression incidence N= 20,723 |
|---|---|
| | Adjusted OR (95% CI) |
| Diabetes* (Yes vs. no) | 1.22 (1.05 – 1.41) |
| Immigrant (Yes vs. no) | 1.13 (0.97 – 1.30) |
| Sex | |
| Male | 1 |
| Female | 1.65 (1.47 – 1.85) |
| Age, years, | |
| 71 – 85 | 1 |
| 61 – 70 | 0.80 (0.70 – 0.92) |
| 45 – 60 | 1.01 (0.86 – 1.17) |
| Province | |
| Quebec | 1 |
| British Columbia | 0.68 (0.58 – 0.81) |
| Ontario | 0.64 (0.54 – 0.76) |
| Other | 0.78 (0.68 – 0.90) |
| Medical conditions (Yes vs. no) | |
| Living with pain | 1.75 (1.96 – 1.56) |
| Bowel disorders | 1.42 (1.19 – 1.68) |
| Smoking status | |
| Smoker | 1 |
| Former smoker | 0.45 (0.38 – 0.55) |
| Non-smoker | 0.50 (0.42 – 0.61) |
| Weight change † | |
| Same weight | 1 |

| | |
|---|---|
| Gained weight | 1.33 (1.14 – 1.55) |
| Lost weight | 1.31 (1.13 – 1.51) |
| Sleep quality | |
| Satisfied or very satisfied | 1 |
| Neutral | 1.30 (1.12 – 1.52) |
| Dissatisfied or very dissatisfied | 1.87 (1.65 – 2.13) |

OR= Odds Ratio; CI= Confidence Interval;

* The multiple imputation model adjusted for all the variables included in Table 1.
Diabetes at baseline is assessed with a positive answer to "Has a doctor ever told you that you have diabetes, borderline diabetes or that your blood sugar is higher?" At 3-year follow-up, depression is defined using CES-D-10 score ≥ 10 or currently taking medication for depression for cohort1.

† Weight change is defined by the question "Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"

Table 6: Sensitivity analysis of the association between baseline depression and diabetes at three years: missing baseline data were imputed using multiple imputation

| | Cohort 2: Diabetes incidence N= 22,041 Adjusted OR (95% CI) |
|---|---|
| Depression* (Yes vs. no) | 1.31 (1.12 - 1.54) |
| Immigrant (Yes vs. no) | 0.96 (0.80 - 1.15) |
| Sex | |
| Male | 1 |
| Female | 1.21 (1.05 - 1.40) |
| Age, years, | |
| 45 - 60 | 1 |
| 61 - 70 | 0.95 (0.82– 1.27) |
| 71 - 85 | 0.73 (0.60 – 0.89) |
| Province | |
| Quebec | 1 |
| British Columbia | 1.13 (0.92 – 1.39) |
| Ontario | 0.99 (0.81 – 1.21) |
| Other | 0.75 (0.62 – 0.90) |
| Medical conditions (Yes vs. no) | |
| Hypertension | 1.25 (1.05 – 1.49) |
| Heart disease | 1.43 (1.20 – 1.69) |
| Waist circumference risk (Yes vs. no) | 2.21 (1.91- 2.56) |
| Weight change † | |
| Same weight | 1 |
| Gained weight | 0.99 (1.12 - 1.43) |
| Lost weight | 1.25 (1.06 - 1.49) |

OR= Odds Ratio; CI= Confidence Interval;

* The multiple imputation model adjusted for all the variables included in Table 1. Depression is assessed with Center for Epidemiological Studies Depression 10 Scale, CES-D ≥ 10 or currently taking medication for depression or following any other treatments for depression. 3-year incident diabetes is defined using self-reported diabetes diagnosis. † Weight change is defined by the question "Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"

## Appendix C: Manuscript 3 supplemental

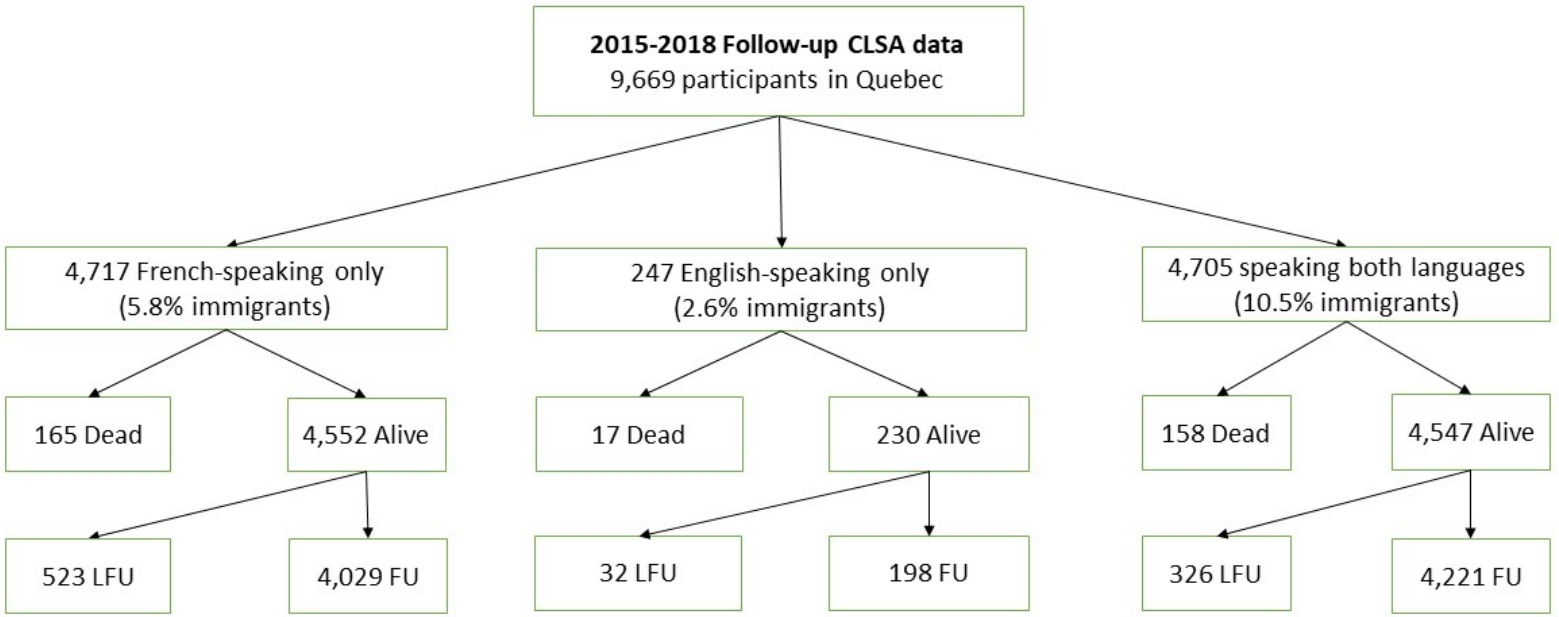


Figure 1a. Flow chart depicting the construction of the study cohort of participants living in French-speaking majority Quebec
CLSA: Canadian Longitudinal Study on Aging.
FU=Follow-up; LFU=Loss to follow-up or withdrawn

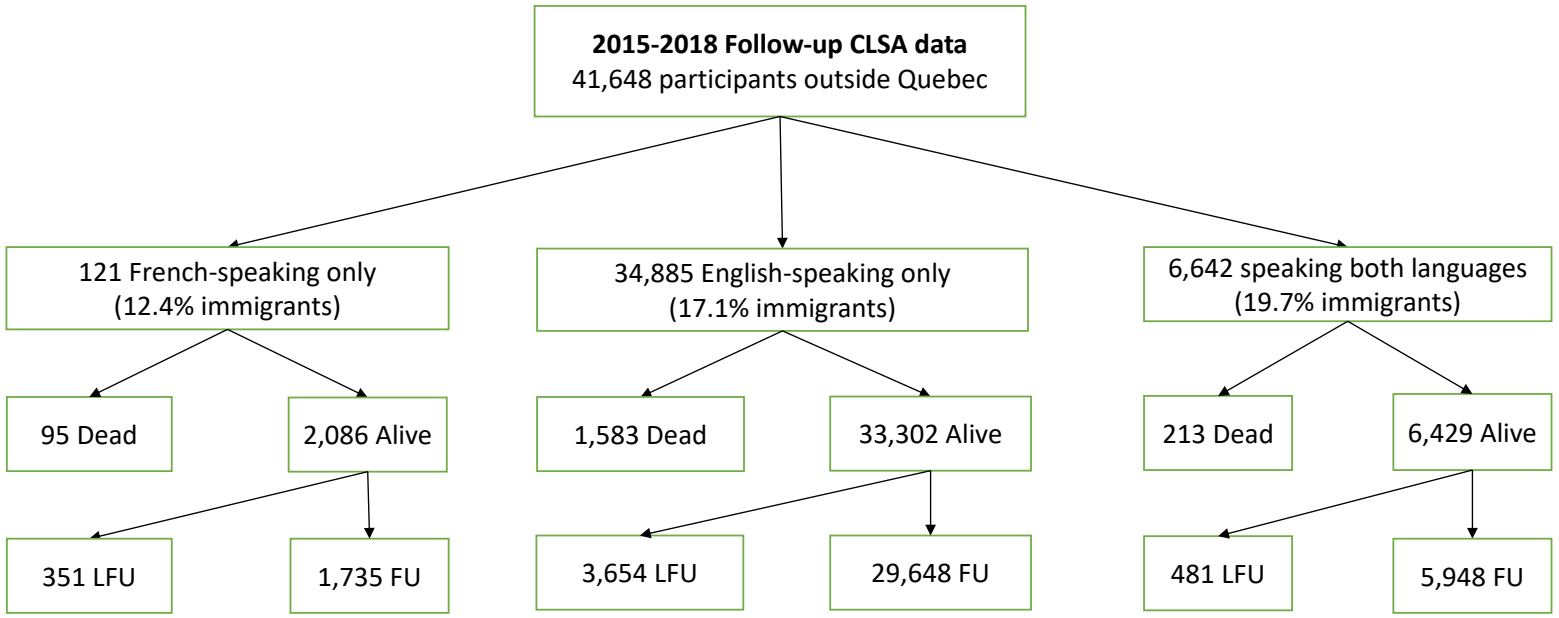


Figure 1b. Flow chart depicting the construction of the study cohort of participants living in English-speaking majority provinces outside Quebec.
CLSA: Canadian Longitudinal Study on Aging.
FU=Follow-up; LFU=Loss to follow-up or withdrawn

Table 1a: Baseline characteristics and multinomial logistic regression of language in French-speaking majority province, Quebec.

| | Quebec | | |
|---|---|---|---|
| | Overall | Bilingual vs. French majority* | English minority vs. French majority* |
| | N= 9,329 | N= 8,123 | |
| | N (%) | Adjusted OR (95% CI) | |
| Age, y | | | |
| 45-60 | 4,324 (46.4) | 1 | 1 |
| 61-70 | 2,874 (30.8) | 1.34 (1.17 - 1.53) | 2.63 (1.59 - 4.34) |
| 71-86 | 2,131 (22.8) | 1.46 (1.25 - 1.71) | 4.01 (2.32 – 6.94) |
| Sex | | | |
| Male | 4,490 (48.1) | 1 | 1 |
| Female | 4,839 (51.9) | 0.68 (0.62 - 0.74) | 1.02 (0.74 - 1.40) |
| Marriage | | | |
| Single | 1,301 (13.9) | | |
| Married | 5,672 (60.8) | - | - |
| Widowed/divorced/separated | 2,354 (25.2) | | |
| Language of conversation | | | |
| French | 4,552 (48.8) | | |
| English | 230 (2.5) | - | - |
| Bilingual | 4,547 (48.7) | | |
| Non-immigrant | 8,484 (90.9) | 1 | 1 |
| Immigrant | 845 (9.1) | 1.77 (1.48 - 2.13) | 15.2 (10.9 - 21.4) |
| Years since arrival to Canada | | | |
| ≤ 20 years | 200 (2.1) | - | - |

| | | | |
|---|---|---|---|
| > 20 years | 645 (6.9) | | |
| Age at arrival in Canada (years old) | | | |
| ≤ 22 years | 289 (3.1) | - | - |
| > 22 years | 556 (6.0) | | |
| Ethnicity and race | | | |
| White | 9,065 (97.2) | | |
| Black | 90 (1.0) | - | - |
| South Asian | 19 (0.2) | | |
| Chinese | 14 (0.2) | | |
| First Nations | 134 (1.4) | | |
| Social support** | | | |
| Low | 4,887 (52.4) | - | - |
| High | 4,442 (47.6) | | |
| Seen a psychologist in the past year | | | |
| No | 8,399 (90.0) | | |
| Yes | 506 (5.4) | - | - |
| Total household income | | | |
| < 20,000$ | 805 (8.6) | 1 | 1 |
| 20,000-50,000$ | 2,815 (30.2) | 1.12 (0.93 - 1.37) | 0.83 (0.50 - 1.37) |
| 50,000-100,000$ | 3,147 (33.7) | 1.57 (1.30 - 1.90) | 1.02 (0.59 - 1.74) |
| > 100,000$ | 2,011 (21.6) | 2.67 (2.16 - 3.30) | 1.41 (0.75 - 2.68) |
| Working status | | | |
| Unemployed | 466 (5.0) | 1 | 1 |
| Employed | 3,522 (37.8) | 0.80 (0.63 – 1.00) | 0.83 (0.35 - 1.97) |
| Retired | 5,288 (56.7) | 0.68 (0.53 - 0.86) | 0.91 (0.38 - 2.18) |
| Education level | | | |
| < Post-secondary degree/diploma | 2,171 (23.3) | 1 | 1 |
| Post-secondary degree/diploma | 7,158 (76.7) | 1.99 (1.76 - 2.24) | 1.13 (0.77 - 1.65) |

| | | | |
|---|---|---|---|
| Setting | | | |
| Urban | 6,627 (71.0) | | |
| Rural | 2,628 (28.2) | - | - |
| Medical Conditions (Yes vs. No) | | | |
| Living with pain | 3,885 (41.6) | 0.88 (0.80 - 0.97) | 0.80 (0.58 - 1.10) |
| Bowel disorders | 651 (7.0) | - | - |
| Diabetes | 1,456 (15.6) | - | - |
| Arthritis | 202 (2.2) | - | - |
| Heart Disease | 2,155 (23.1) | - | - |
| Cancer | 1,092 (11.7) | - | - |
| Hypertension | 3,513 (37.7) | - | - |
| Alcohol consumption | | | |
| Never | 763 (8.2) | 1 | 1 |
| About 1-4 times a month | 3,886 (41.7) | 0.98 (0.82 - 1.18) | 0.54 (0.34 - 0.87) |
| ≥ 2 times a week | 4,495 (48.2) | 1.25 (1.04 - 1.50) | 0.59 (0.36 – 0.96) |
| Smoking Status | | | |
| Smoker | 2,855 (30.6) | | |
| Former smoker | 3,207 (34.4) | - | - |
| Non-smoker | 3,251 (34.8) | - | - |
| Nutritional risk status | | | |
| Low risk | 5,690 (61.0) | - | - |
| High risk | 3,138 (33.6) | | |
| Weight classification † | | | |
| Underweight | 85 (0.9) | - | - |
| Normal weight | 3,034 (32.5) | | |
| Overweight | 3,810 (40.8) | | |
| Obese | 2,350 (25.2) | | |
| Weight change ‡ | | | |
| Same weight | 6,037 (64.7) | - | - |

| | | | |
|---|---|---|---|
| Gained weight | 1,364 (14.6) | | |
| Lost weight | 1,492 (16.0) | | |
| Cohort type | | | |
| Tracking | 3,437 (36.8) | 1 | 1 |
| Comprehensive | 5,892 (63.2) | 1.75 (1.59 - 1.93) | 1.24 (0.89 - 1.74) |

SD= Standard Deviation

* Language is defined using the language that “you can conduct a conversation with” coded as English only, French only or bilingual. French: can converse in French with or without any other language but English; English: can converse in English with or without any other language but French; Bilingual: can converse in English and French with or without any other language. In Quebec, the majority official language is French.

The multinomial logistic model to compare the baseline characteristics by language groups adjusted for all the variables included in Table 1. Sex, age, and cohort type were forced in the model.

† Based on Body Mass Index international classification for adults ≥ 18 years of age.

‡ Weight change is defined by the question "Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"

Table 1b: Baseline characteristics and multinomial logistic regression of language in English-speaking majority provinces outside of Quebec

| | Overall | Outside Quebec | |
|---|---|---|---|
| | | Bilingual vs. English majority* | French minority vs. English majority* |
| | N= 39,850 | N= 31,685 | |
| Age, y | N (%) | Adjusted OR (95% CI) | |
| 45-60 | 18,206 (45.7) | 1 | 1 |
| 61-70 | 11,843 (29.7) | 1.11 (1.04 - 1.19) | 0.78 (0.47 - 1.29) |
| 71-86 | 9,801 (24.6) | 0.93 (0.85 - 1.01) | 0.58 (0.33 – 1.03) |
| Sex | | | |
| Male | 19,395 (48.7) | 1 | 1 |
| Female | 20,455 (51.3) | 1.10 (1.04 - 1.17) | 1.30 (0.83 - 2.03) |
| Marriage | | | |
| Single | 2,867 (7.2) | - | - |
| Married | 28,369 (71.2) | | |
| Widowed/divorced/separated | 8,602 (21.6) | | |
| Language of conversation | | | |
| French | 119 (0.3) | - | - |
| English | 33,302 (83.6) | | |
| Bilingual | 6,429 (16.1) | | |
| Non-immigrant | 32,887 (82.5) | 1 | 1 |
| Immigrant | 6,963 (17.5) | 1.14 (1.06 - 1.23) | 0.92 (0.49 – 1.75) |
| Years since arrival to Canada | | | |
| ≤ 20 years | 786 (2.0) | - | - |
| > 20 years | 6,177 (15.5) | | |
| Age at arrival in Canada (years old) | | | |

| | | | |
|---|---|---|---|
| ≤ 22 years | 3,392 (8.5) | - | - |
| > 22 years | 3,571 (9.0) | | |
| Ethnicity and race | | | |
| White | 38,151 (95.7) | - | - |
| Black | 258 (0.6) | | |
| South Asian | 388 (1.0) | | |
| Chinese | 291 (0.7) | | |
| First Nations | 719 (1.8) | | |
| Social support** | | | |
| Low | 19,521 (49.0) | - | - |
| High | 20,329 (51.0) | | |
| Seen a psychologist in the past year | | | |
| No | 35,781 (89.8) | - | - |
| Yes | 1,564 (3.9) | | |
| Total household income | | | |
| < 20,000$ | 1,899 (4.8) | 1 | 1 |
| 20,000-50,000$ | 8,563 (21.5) | 0.96 (0.81 - 1.14) | 0.64 (0.34 - 1.19) |
| 50,000-100,000$ | 13,370 (33.6) | 1.09 (0.92 - 1.30) | 0.22 (0.11 – 0.45) |
| > 100,000$ | 13,457 (33.8) | 1.49 (1.26 - 1.77) | 0.11 (0.04 - 0.26) |
| Working status | | | |
| Unemployed | 1,772 (4.4) | - | - |
| Employed | 16,226 (40.7) | | |
| Retired | 21,722 (54.5) | | |
| Education level | | | |
| < Post-secondary degree/diploma | 6,707 (16.8) | 1 | 1 |
| Post-secondary degree/diploma | 33,143 (83.2) | 2.22 (1.99 - 2.48) | 0.66 (0.42 - 1.04) |

| | | | |
|---|---|---|---|
| Setting | | | |
| Urban | 29,665 (74.4) | | |
| Rural | 7,891 (19.8) | - | - |
| Medical Conditions | | | |
| Living with pain | 13,816 (34.7) | - | - |
| Bowel disorders | 3,920 (9.8) | - | - |
| Diabetes | 6,745 (16.9) | - | - |
| Arthritis | 1,718 (4.3) | - | - |
| Heart Disease | 8,676 (21.8) | - | - |
| Cancer | 6,111 (15.3) | - | - |
| Hypertension | 14,476 (36.3) | - | - |
| Alcohol consumption | | | |
| Never | 4,944 (12.4) | 1 | 1 |
| About 1-4 times a month | 16,692 (41.9) | 1.12 (1.01 - 1.24) | 1.38 (0.76 – 2.51) |
| ≥ 2 times a week | 16,977 (42.6) | 1.40 (1.27 - 1.56) | 0.69 (0.34 – 1.43) |
| Smoking Status | | | |
| Smoker | 11,903 (29.9) | | |
| Former smoker | 16,688 (41.9) | - | - |
| Non-smoker | 11,177 (28.0) | - | - |
| Nutritional risk status | | | |
| Low risk | 24,012 (60.3) | 1 | 1 |
| High risk | 12,951 (32.5) | 0.84 (0.78 - 0.90) | 0.67 (0.41 - 1.09) |
| Weight classification † | | | |
| Underweight | 277 (0.01) | - | - |
| Normal weight | 12,062 (30.3) | | |
| Overweight | 16,172 (40.6) | | |
| Obese | 11,165 (28.0) | | |
| Weight change ‡ | | | |
| Same weight | 24,531 (61.6) | 1 | 1 |

| | | | |
|---|---|---|---|
| Gained weight | 5,731 (14.4) | 1.08 (0.99 - 1.17) | 1.22 (0.68 - 2.19) |
| Lost weight | 7,044 (17.7) | 1.18 (1.09 - 1.27) | 0.82 (0.43 - 1.58) |
| Cohort type | | | |
| Tracking | 16,627 (41.7%) | 1 | 1 |
| Comprehensive | 23,223 (58.3) | 1.15 (1.08 - 1.22) | 0.22 (0.13 - 0.37) |

SD= Standard Deviation

* Language is defined using the language that "you can conduct a conversation with" coded as English only, French only or bilingual. French: can converse in French with or without any other language but English; English: can converse in English with or without any other language but French; Bilingual: can converse in English and French with or without any other language. Outside Quebec, the majority official language is English.

The multinomial logistic model to compare the baseline characteristics by language groups adjusted for all the variables included in Table 1. Sex, age, and cohort type were forced in the model.

† Based on Body Mass Index international classification for adults ≥ 18 years of age.

‡ Weight change is defined by the question "Compared with 6 months ago, have you gained weight, lost weight, or stayed about the same?"

Table 2: The impact of language on loss to follow-up at three years by baseline depressive symptoms: Multivariable logistic regression model

| | Loss to follow-up vs. not loss to follow-up | |
|---|---|---|
| | Depressed** N= 7,902 | Not depressed N= 41,120 |
| Language conversation* | | |
| English | 1 | 1 |
| French | 0.72 (0.47 – 1.12) | 1.19 (0.89 - 1.58) |
| Bilingual | 0.72 (0.54 - 0.95) | 0.85 (0.71 – 1.02) |
| Years since arrival to Canada | | |
| Non-immigrant | 1 | 1 |
| ≤ 20 years | 1.29 (0.84 – 1.34) | 2.20 (1.58 – 3.05) |
| > 20 years | 1.06 (0.84 – 1.34) | 0.94 (0.79 – 1.11) |
| Sex | | |
| Male | 1 | 1 |
| Female | 0.90 (0.76 – 1.06) | 0.88 (0.79 – 0.99) |
| Age, years, | | |
| 45 - 60 | 1 | 1 |
| 61 - 70 | 0.75 (0.62 – 0.91) | 0.89 (0.78 – 1.02) |
| 71 - 85 | 0.97 (0.80 – 1.18) | 1.30 (1.13 – 1.49) |
| Total household income | | |
| < 20,000$ | 1 | 1 |
| 20,000-50,000$ | 0.70 (0.56 - 0.87) | 0.67 (0.54 - 0.83) |
| 50,000-100,000$ | 0.47 (0.37 - 0.60) | 0.48 (0.39 - 0.60) |
| > 100,000$ | 0.38 (0.28 - 0.50) | 0.42 (0.33 - 0.53) |
| Education level | | |
| < Post-secondary school | 1 | 1 |
| Post-secondary degree/diploma | 0.68 (0.57 - 0.81) | 0.64 (0.56 - 0.73) |
| Alcohol consumption | | |
| Never | 1 | 1 |
| About 1-4 times/month | 0.78 (0.64 - 0.95) | 0.77 (0.65 - 0.90) |
| ≥ 2 times a week | 0.61 (0.48 - 0.76) | 0.69 (0.58 - 0.81) |

| | | |
|---|---|---|
| Nutritional risk (Yes vs. No) | - | 1.26 (1.11 - 1.42) |
| Cohort type (Comprehensive vs. Tracking) | 0.47 (0.40 – 0.55) | 0.47 (0.42 – 0.53) |
| Age at arrival in Canada (years old) ‡ | | |
| Non-immigrant | 1 | 1 |
| ≤ 22 | 0.85 (0.62 – 1.18) | 0.85 (0.68 – 1.07) |
| > 22 | 1.32 (0.99 – 1.75) | 1.39 (1.14 - 1.70) |

OR= Odds Ratio; CI= Confidence Interval; LFU= loss to follow-up (withdrawn or did not provide data at 3-year follow-up).
*Language is defined using the language that "you can conduct a conversation with" coded as English only, French only or bilingual. French: can converse in French with or without any other language but English; English: can converse in English with or without any other language but French; Bilingual: can converse in English and French with or without any other language. The model adjusted for all the variables included in Table 1. Sex, age, cohort type, and province were forced in the model.
**Depressive symptoms is assessed with Center for Epidemiological Studies Depression 10 Scale, CES-D-10 ≥ 10.
‡These results are from a separate model with age at arrival rather than years since arrival in Canada.

Table 3. Association of language and loss to follow-up by years since arrival in Canada since immigration: Multivariable logistic regression model

| | Loss to follow-up vs. Not loss to follow-up | | |
|---|---|---|---|
| | Model 1: In non-immigrants N= 41,371 | Model 2: In immigrants who resided ≤ 20 years in Canada N= 986 | Model 3: In immigrants who resided > 20 years in Canada N= 6,822 |
| | Adjusted OR (95% CI) | | |
| Language conversation* | | | |
| English | 1 | 1 | 1 |
| French | 1.20 (0.91 – 1.59) | 1.09 (0.39 – 3.04) | 0.75 (0.32 – 1.78) |
| Bilingual | 0.85 (0.71 - 1.02) | 0.85 (0.44 – 1.64) | 0.93 (0.64 –1.35) |
| Sex | | | |
| Male | 1 | 1 | 1 |
| Female | 0.91 (0.82 - 1.02) | 0.72 (0.47 – 1.11) | 0.81 (0.65 – 0.99) |
| Age, years, | | | |
| 45 - 60 | 1 | 1 | 1 |
| 61 - 70 | 0.90 (0.79 – 1.02) | 0.55 (0.29 – 1.02) | 0.87 (0.67 – 1.14) |
| 71 - 85 | 1.24 (1.09 – 1.42) | 0.80 (0.34 – 1.87) | 1.13 (0.87 – 1.47) |
| Province** | | | |
| Quebec | 1 | 1 | 1 |
| Outside Quebec | 1.15 (0.91 - 1.45) | 1.48 (0.62 – 3.53) | 0.76 (0.49 – 1.18) |
| Total household income | | | |
| < 20,000$ | 1 | 1 | 1 |
| 20,000-50,000$ | 0.63 (0.53 - 0.76) | 0.71 (0.34 – 1.87) | 1.03 (0.69 – 1.52) |
| 50,000-100,000$ | 0.46 (0.38 - 0.56) | 0.43 (0.21 - 0.89) | 0.56 (0.37 – 0.83) |
| > 100,000$ | 0.41 (0.34 - 0.51) | 0.18 (0.08 - 0.38) | 0.41 (0.26 – 0.63) |
| Alcohol consumption | | | |
| Never | 1 | | 1 |
| About 1-4 times/month | 0.78 (0.67 – 0.90) | - | 0.82 (0.60 – 1.11) |
| ≥ 2 times a week | 0.69 (0.59 – 0.81) | | 0.58 (0.42 – 0.81) |

| | | | |
|---|---|---|---|
| Cohort type (Comprehensive vs. Tracking) | 0.49 (0.44 – 0.55) | 0.49 (0.32 – 0.75) | |

OR= Odds Ratio; CI= Confidence Interval; LFU= loss to follow-up (withdrawn or did not provide data at 3-year follow-up).
*Language is defined using the language that "you can conduct a conversation with" coded as English only, French only or bilingual. French: can converse in French with or without any other language but English; English: can converse in English with or without any other language but French; Bilingual: can converse in English and French with or without any other language. The model adjusted for all the variables included in Table 1. Sex, age, cohort type, and province were forced in the model.