Global Problems with Local Impacts: Exploring the Health Impacts of Climate Change and Air Pollution in Older Adults and Immigrants Living in Canada

by

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A thesis submitted in partial fulfillment of the requirements for the degree of

Master of Science

in

Epidemiology

School of Public Health
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ABSTRACT

As human actions continue to drive global climate change and increase air pollution, these two closely related environmental phenomena pose a significant threat to public health. Because of Canada's geographical location, it is warming at twice the rate of the global average, which is expected to amplify adverse health impacts via direct and indirect pathways. The cyclical relationship between climate change and air pollution can, in some cases, compound and intensify morbidity and mortality even where there are low levels of ambient air pollution. While all populations will be impacted, some populations, such as older adults and immigrant communities, may bear a disproportionate amount of the health risk. With estimates of life expectancy continually increasing, an aging baby-boom generation, and rising levels of immigration to metropolitan centers, these groups are vulnerable. Since health impacts are heavily influenced by local environmental and socioeconomic contexts, the aim of this research is to explore drivers of health risk and resilience associated with climate and air pollution in older adults and immigrants living in Canada. Insights generated through this work will help fill an existing knowledge gap in Alberta and help inform community-level planning activities for effective adaptation measures targeted at protecting health.

A scoping review methodology was used in Chapter 2 to identify peer-reviewed articles published from 2010 to June 2020 focused on the health of older adults and immigrants living in Canada, where the primary exposures were related to climate or air pollution. Following abstract and full-text screening by two independent reviewers, data from the 52 included articles on setting, exposures, health outcomes, and other sociodemographic and environmental contextual factors were extracted. While older people in Canada experience health risks due to climate and air pollution exposures, the extent of the risk depends on multiple factors. There was little published information about the climate and air pollution-related health impacts experienced by immigrant communities. Future work is needed to investigate

what promotes or reduces resiliency to the health impacts of climate- and air pollution-related hazards in Canada's older adults and immigrant communities. Of the 52 included articles, most considered populations in Ontario (n=25) and Quebec (n=20). Due to the expansive and diverse geography of Canada, future research should also consider understudied rural and urban areas, Prairie Provinces, and those in the North.

In Chapter 3, the Intergovernmental Panel on Climate Change Fifth Assessment Report risk framework was used to guide an ecological correlation study focused on older adult and immigrant communities in Edmonton, AB in. Prevalence rate ratios (PRR) from negative binomial regressions were used to estimate the effects of exposure to climate change and air pollution hazards on the rate of adverse cardiovascular, injury, mental, and respiratory health events at the dissemination area (DA) level between 2015-18 within the context of a community-level vulnerability (sensitivity, adaptive capacity). Higher proportions of older adults associated with increased rates of cardiovascular, injury, mental, and respiratory health events (PRR [95%CI] = 1.051 [1.044, 1.058]; 1.041 [1.037, 1.045]; 1.027 [1.021, 1.033]; 1.022 [1.018, 1.027]). Rates of injuries and respiratory events increased with increasing proportions of refugees (PRR [95%CI] = 1.007 [1.001, 1.013]; 1.017 [1.011, 1.024]). Higher proportions of economic immigrants demonstrated protective effects for cardiovascular, injury, and mental health events (PRR=0.990 [0.985, 0.996]; 0.993 [0.989, 0.996]; 0.984 [0.979, 0.989]). Associations between climate change and air pollution hazards were dependent upon the type of health event. The effects of certain hazards depended on the proportions of immigrants and older adults in a DA (heat effect on injury rates: PRR [95%CI] = 0.865 [0.809, 0.925] at 5% ≥65 years; 1.110 [1.011, 1.219] at 25% ≥65 years). Findings from this thesis can be incorporated into community-level planning and adaptive strategies to effectively reduce disproportionate impacts and protect health.

PREFACE

This thesis is a compilation of an original work by McKenzie H. Tilstra under the supervision of Drs. Shelby Yamamoto, Bernadette Quemerais, Allyson Jones, and Alvaro Osornio-Vargas. The research presented in this thesis is part of larger collaborative research and development projects in partnership with the City of Edmonton, Alberta EcoTrust, and the North American Partnership for Environmental Community Action (NAPECA). The research project of which this thesis is a part received research approval from the University of Alberta Health Research Ethics Board, Project Name "Climate Change, Older Adults and Immigrants: Exploring Community Vulnerability and Resilience," PRO. 00094359, December 3, 2019.

Chapter 2 of this thesis has been published as M.H. Tilstra, I. Tiwari, L. Niwa, S. Campbell, C.C. Nielsen, C.A. Jones, A. Osornio Vargas, O. Bulut, B. Quemerais, J. Salma, K. Whitefield, and S.S. Yamamoto, "Risk and Resilience: How Is the Health of Older Adults and Immigrant People Living in Canada Impacted by Climate- and Air Pollution-Related Exposures?," *International Journal of Environmental Research and Public Health*, vol. 18, issue 20, article 10575. Author contributions are as follows: Conceptualization, M.H.T. and S.S.Y.; methodology, S.C.; screening, M.H.T. and I.T.; extraction, M.H.T. and L.N.; writing— original draft preparation, M.H.T.; writing—review and editing, S.C., C.C.N., C.A.J., A.O.V., O.B., B.Q., J.S., K.W. and S.S.Y.; supervision, S.S.Y., C.A.J., B.Q. and A.O.V.

DEDICATION

Written in dedication to my grandmothers, two older adult immigrant women on whose shoulders I stand. I would not be where I am today without your hard work, sacrifice, and endless love and support.

ACKNOWLEDGEMENTS

As a Canadian settler and granddaughter of Dutch immigrants, I acknowledge that I was situated within and worked towards this MSc on Treaty 6 Territory, a traditional gathering place for diverse Indigenous Peoples including the Cree, Blackfoot, Métis, Nakota Sioux, Iroquois, Dené, Ojibway/Saulteaux/Anishinaabe, and Inuit.

Thank you to Amiskwaciy Waskahikan, the city of Edmonton, and the amazing people who call it home. The river valley was a haven for me during the long months of the COVID-19 pandemic, but more than that, this city has been the garden in which I grew for the last six years. It was an honor to be able to dedicate my time as a master's student to my home.

My *sincerest* thanks to my committee, Dr. Bernadette Quemerais, Dr. Allyson Jones, and Dr. Alvaro Osornio-Vargas for your guidance and support in navigating the winding pathway of my master's thesis. Your support and feedback have been essential in my growth as a researcher.

A special thanks to you, my supervisor, Shelby. You and your endless kindness, support, and patience made my graduate experience one of the most meaningful, growth-filled times in my life. I am so lucky and grateful to have had the chance to work with such a brilliant woman in science, a fantastic teacher, and an even better person. I *cannot* thank you enough.

Thank you to everyone in CHEER Lab. Dr. Charlene Nielsen and Ishwar Tiwari, I could not have accomplished this work without you; thank you for being my friends and mentors through this process. To Chunhui Tian, Tianqi Zhao, Holly Sullivan, Sammy Lowe, Brooke Sidney, and Majid Bagheri thank you for listening, giving feedback, and contributing to the bright, innovative environment at CHEER Lab.

To my friends and classmates at the School of Public Health, it was a pleasure to work and learn alongside you (Danny and Greg, you got me through biostatistics). To the 2020 SPHSA team, it was an honor and inspiration to work with you. A special shout-out to my classmate, colleague, and dear friend Edwina Veerasingham; to say I would not have survived my master's thesis during this pandemic without you, is an understatement.

Jaret, Anna, Ryleigh, Rachel, Amanda, and Katie –thank you for doing life with me, regardless of any physical (or social) distance. Our video chats, phone calls, Netflix parties, commiseration over the trials of graduate studies, socially distanced picnics, roommate movie nights, river valley walks, and so much more kept me grounded (and sane).

Mom, Dad, and Tasha, your continued encouragement, love, and faith in my abilities has carried me through, always. This journey was not without its bumps, potholes, and detours and having you with me every step has meant everything.

Navigating this master's program was an adventure of no small proportions, and I have grown with and been shaped by the many people who have walked with me these past two and half years. Thank you all, for everything.

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1 BACKGROUND

1.1 THE CLIMATE CRISIS

The global average surface temperature has risen approximately 1^oC above pre-industrial levels and heading towards a 1.5^oC increase by 2030-2050 at the current rate of emissions [1]. The Intergovernmental Panel on Climate Change (IPCC) projects that at this current rate of global warming, we will experience unprecedented changes, including increased frequency of extreme temperatures and weather events, flooding and drought, wildfires and decreased air quality, sea-level rise, water scarcity, and losses to biodiversity [1,2]. If we continue along our current trajectory, we are racing towards harmful and potentially cataclysmic consequences for human and natural environmental systems [1–3].

1.2 DEFINING ISSUES FOR PUBLIC HEALTH IN THE 21ST CENTURY

The unprecedented changes in our environment due to climate change pose a significant threat to human health and well-being. Climate change is considered "the defining issue" for public health in the 21st century [4]. Climate change has a close relationship with air pollution [5]. Climate-altering pollutants contribute to climate change, and climate change can subsequently impact air quality through increasing ground-level ozone (O_3) concentrations and higher frequencies of wildfires [5,6]. Already associated with an estimated 4.2 million premature deaths globally, air pollution is considered the single most significant environmental health risk by the WHO [7,8]. Consequently, this relationship augments the complexity of these multifaceted public health issues. Increasingly volatile weather patterns, associated environmental disasters, and changes to air quality serve as direct and indirect drivers of health risk (Figure 1.1) [9–11]. Having already observed a rise in climate-sensitive health outcomes, the health burden is expected to continue increasing with global temperatures [2,9,10].

A growing body of evidence has linked climate change and air pollution hazards and the increasing burden of poor health from cardiovascular disease, respiratory disease, injury, and mental illness [2,12–20]. High temperatures (99th percentile) have been shown to increase coronary heart disease by 6% (95% CI 1, 11) relative optimal temperatures [21]. Increased risk of congestive heart failure has also been associated with an interquartile range increase in exposure to nitrogen dioxide (NO_2, HR= 1.02

(95% CI: 1.01, 1.04)), ground level ozone (O_3, 1.03 (1.02, 1.03)), and fine particulate matter ($PM_{2.5}$, 1.05 (1.04, 1.05)) [22]. Reviews have found that both meteorological and air pollution (particularly O_3 and $PM_{2.5}$) parameters increase respiratory morbidity, especially in those with chronic respiratory diseases such as asthma and COPD [14]. In some cases, a harmful synergy between climate change hazards and air pollution can intensify health risks; studies have shown poor air quality can compound the adverse health effects of heatwaves [6,13,14,19].

The increasing health burden associated with climate change and air pollution is not likely to be evenly distributed across the general population. Current epidemiological evidence synthesized in the IPCC Fifth Assessment Report indicates that people with pre-existing chronic conditions, low socioeconomic status (SES), limited access to health care and public health services, and equity-seeking groups are likely to bear a disproportionate amount of the health risk, as the climate continues to shift [2].
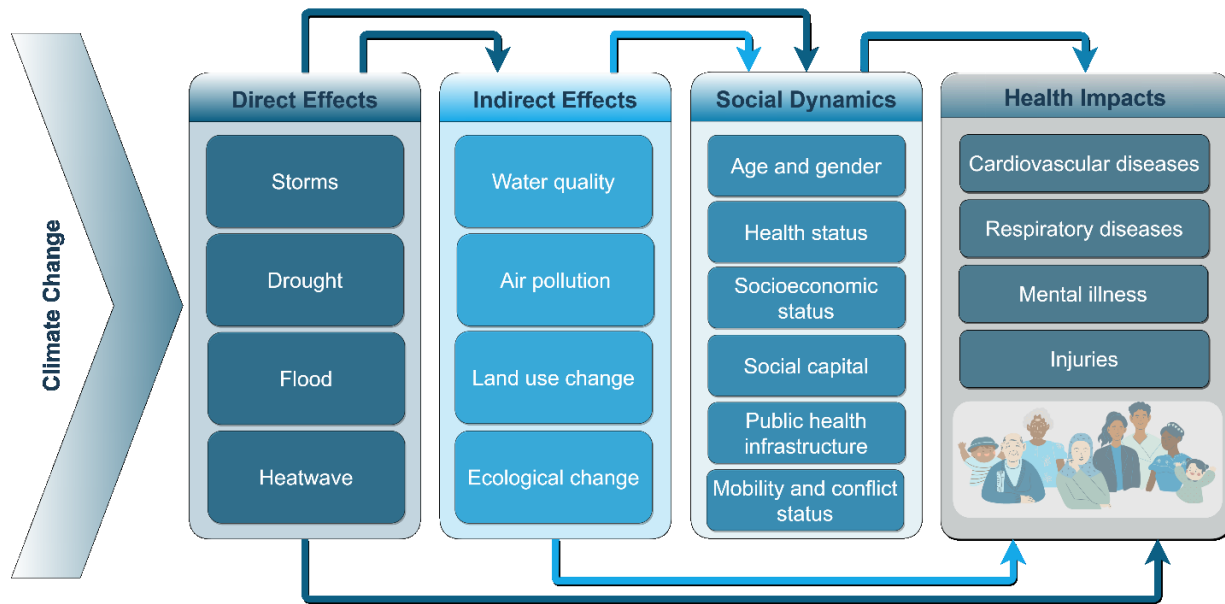
Figure 1.1 Health impacts of climate change adapted from Watts et al. [10]

1.3 A GLOBAL PROBLEM, LOCAL IMPACTS: THE IMPORTANCE OF PLACE

The pattern and rate of climate change are driving a rise in the global burden of adverse health impacts, which emerge differently depending on location. The direct and indirect effects of climate change (Figure 1.1) will vary according to local geographic and environmental factors, as will the socioeconomic and demographic features of the communities in which people live, work, and play (Figure 1.2). Similarly, exposure to air pollution will vary according to place. While climate (and air pollution) impacts

will be observed at all spatial scales, the magnitude of experienced health risk will be determined by location-specific contextual factors (e.g., local weather patterns and air pollutants, social and cultural dynamics, wealth) [23–26].
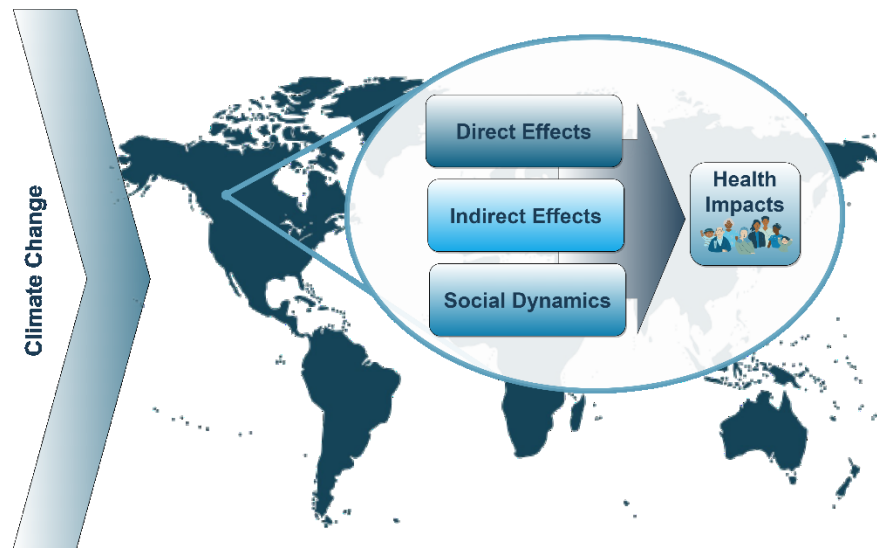
Figure 1.2 The exact socioeconomic dynamics, indirect, and direct effects of global climate change driving health risk depend on location[2,10].

1.4 CLIMATE CHANGE, AIR POLLUTION, AND THE HEALTH OF OLDER ADULTS AND IMMIGRANTS IN CANADA

Canada is warming at twice the rate of the global average [27]. Depending on the location geography, this is driving increased frequencies and intensity of storms, wildfires, floods, extreme temperatures, and poor air quality events [27–29]. Climate change and ensuing climate hazards present distinct challenges to the health of the physically/mentally, socially, and culturally diverse communities across the country. Similarly, there is a well-known relationship between air pollution and negative health effects; in Canada, it has been estimated that 15,300 premature deaths are attributable to air pollution each year [30].

Two populations that may face greater health risk in Canada include older adults and immigrants [29]. Physiological changes limit older adults' capacity for thermoregulation compared to younger persons [31]. Other challenges that may predispose older adults are related to multimorbidity, mobility limitations, lack of awareness surrounding environmental hazards, social isolation, and inadequate community social supports that could limit their capacity to cope with the effects of climate [20,31–34].

Understanding how climate change and air pollution hazards affect older adults in Canada will be important as the baby boomer population ages the number of older adults continues to grow [35].

The "healthy immigrant effect" characterizes the relatively good health immigrants arrive with compared to their Canadian-born counterparts, however this has been shown to diminish with time [36]. Immigrant health may be affected by socioeconomic differences, living arrangements, cultural and/or language barriers, occupational exposure, access to healthcare, and racism which could worsen climate change effects in this population [36–41]. Immigrants and refugees make up a fifth of the Canadian population [42], making them a critical public health consideration as the climate changes.

Climate change adaptation will have its limits, especially if we do not take appropriate action to mitigate climate change. However, in the absence of considerable adaptation activities, adverse health effects linked to climate change and air pollution will certainly be exacerbated [2]. It is critical to understand the current health burden associated with climate and air pollution hazards in vulnerable populations, in particular, older adults and immigrants living in Canada. It will also be important to characterize what factors promote risk or resilience to adverse health impacts within people's socioecological contexts. This can then be incorporated in adaptive strategies to effectively reduce disproportionate impacts and protect health, particularly in marginalized populations such as older adults and immigrants.

2 THESIS RESEARCH AIMS AND OBJECTIVES

This thesis is part of larger collaborative research and development projects in partnership with community stakeholders, researchers, healthcare professionals, the City of Edmonton, Alberta EcoTrust, and the North American Partnership for Environmental Community Action (NAPECA). The projects aimed to develop an index and mapping tools that can be used to visualize and monitor community-health risk and vulnerability to climate change and air pollution hazards in Edmonton, Alberta, Canada. Because older adults and immigrants may be more vulnerable to these hazards, the focus of this work will examine these two groups.

To inform the development of the above-mentioned index and mapping tools as well as community-level planning activities targeted at protecting health, this research aimed to explore health risk and resilience associated with climate change and air pollution in older adults and immigrants living in Canada, and specifically Edmonton, AB. The objectives of this research were as follows:

1. Investigate the state of published research on the health impacts of exposure to climate change and air pollution hazards in older adults and immigrants living in Canada; and

2.

    a. Explore the community-level health impacts associated with exposure to climate change- and air pollution-related hazards on older adult and immigrant populations living in Edmonton, AB and;

    b. Identify relevant sociodemographic and environmental indicators that further characterize community vulnerability to these adverse health impacts.

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Chapter 2: Risk and resilience: how is the health of older adults and immigrant people living in Canada impacted by climate-and air pollution-related exposures?

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ABSTRACT

Background: In the rapidly shifting Canadian climate, an ageing population, and increased migration, a greater understanding of how local climate and air pollution hazards impact older adults and immigrant populations will be necessary for mitigating and adapting to adverse health impacts.

Objectives: To explore the reported health impacts of climate change and air pollution exposures in older adults and immigrant people living in Canada, identify known factors influencing risk and resilience in these populations and gaps in the literature.

Methods: We searched for research focused on older adults and immigrants living in Canada, published from 2010 onward, where the primary exposures were related to climate or air pollution. We extracted data on setting, exposures, health outcomes, and other relevant contextual factors.

Results and discussion: We identified 52 eligible studies, most focused in Ontario and Quebec. Older people in Canada experience health risks due to climate and air pollution exposures. The extent of the risk depends on multiple factors. We found little information about the climate and air pollution-related health impacts experienced by immigrant communities.

Conclusions: Further research about climate- and air pollution-related exposures, health, and which factors promote or reduce resiliency in Canada's older adults and immigrant communities is necessary.

Keywords: climate change; air pollution; health-impacts; older adults; immigrants.

1   INTRODUCTION

Climate change has been called "the defining issue" for public health in the 21st century [1], and air pollution the single most significant environmental health risk by the WHO [2]. Health impacts of these exposures are felt intensely at a local scale, depending on the socio-environmental context. Canada is warming two times faster than the global average, [3] which is expected to amplify adverse health impacts via multidimensional exposure pathways, including changing weather patterns leading to extreme temperatures, drought, floods, and wildfires [3–5]. Likewise, there is a well-established link between air pollution and adverse health outcomes. Health Canada has estimated that 15,300 premature deaths in Canada each year are attributable to air pollution [6].

Complex relationships between climatic variables (i.e., temperature, precipitation, humidity and wind) and air pollution can also impact human health. For example, the adverse health effects of heatwaves can be compounded by poor air quality [7]. Changes in climate associated with increasing frequency, season, and length of wildfires in Canada can also contribute to air pollution and adverse respiratory, cardiovascular, injury and mental health events [5].

Climate change is expected to exacerbate existing health risks and introduce new ones. However, the high degree of spatial variability in climatic and air pollution exposures across Canada (due to expansive geography, land use, and industry, combined with diverse population demographics and social environments) presents a multifaceted challenge for public health in Canada. Moreover, the health burden may fall disproportionately on specific populations due to intersections of physiological, social, and environmental factors [8–10].

Two populations that may face greater health vulnerability due to climate change and air pollution are older adults and immigrants [10]. In Canada, this has ramifications from a public health perspective given the older adult population continues to grow [11] and immigrants comprised over a fifth of the country's population in 2016 (a share that is projected to increase) [12,13].

Both younger and older adults will face health impacts from climate change and air pollution. However, some older adults may face physiological changes, multi-morbidity, mobility limitations, lack of awareness, social isolation, poor housing conditions, and inadequate access to health and welfare

services which could limit their capacity to cope with these effects compared to younger persons [7,14–18].

While Canadian immigrants may arrive healthier than native-born Canadians, this effect diminishes with time [19]. Furthermore, it is not clear whether this effect exists for older immigrants at all [19]. The health of immigrant populations may also be impacted by socioeconomic differences, living arrangements, cultural and/or language barriers, and occupational exposures (e.g., outdoor) that can exacerbate climate change effects [19–22].

Although recent reviews have focused on climate change resilience and adaptation concerning health, research has not explicitly focused on these population's exposures, sensitivities, and adaptive capacities [21,23]. It is important to explore the impact of climate change and air pollution on specific growing vulnerable groups such as older adults and immigrant communities to inform interventions to reduce disproportionate impacts.

2 METHODS

A scoping review method was used to map the literature on climate and air pollution-related health outcomes in Canada's older adults and immigrant populations. The protocol for the review was developed *a priori* for transparency and replicability and was registered on the Open Science Framework [24]. The review framework was informed and guided by the methodology for scoping reviews defined by Arksey & O'Malley et al. [25]. We followed the research methodology and reporting standards for scoping reviews defined by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses Extension for Scoping Reviews (PRISMA-ScR) [26].

2.1 IDENTIFYING THE RESEARCH QUESTION

We established the following questions to examine and synthesize the range, extent, and nature of published literature in Canada with respect to climate, air-pollution, and health in older adult and immigrant populations:

1. What are the reported health impacts of climate and air pollution-related exposures in older adults and immigrants in Canada?

2. Are there socioeconomic and contextual characteristics that impact the relationship between these exposures and adverse health outcomes in these populations?

2.2 IDENTIFYING RELEVANT STUDIES

A search was constructed and executed by a health research librarian (SC) on nine electronic databases: PROSPERO, OVID Medline, OVID EMBASE, OVID Global Health, OVID PsycInfo, Cochrane Library (CDSR and Central), EBSCO CINAHL, Proquest Dissertations and Theses Global and SCOPUS using a controlled vocabulary (e.g., MeSH, Emtree) and keywords representing the concepts "vulnerable populations" and "climate change" and "health impacts" and "Canada" (Table A1). Databases were searched from 2010 to June 2020. No other limits were applied. Detailed searches are available in the supplementary materials.

2.3 STUDY SELECTION

Citations (3,684) were imported to the Covidence systematic review program and then duplicates (1,141) were removed. A two-staged screening process was conducted by two independent reviewers (κ=0.59) (MT, IT). Titles and abstracts were first screened using a stacked screening form. At the second stage, the full text of each article was then screened. To be included, articles had to: 1) focus on exposure to climatic or air pollution variables; 2) discuss health impacts; 3) report results related to older adults and/or immigrant populations; 4) focus on Canadian populations; and 5) have been published as a peer-reviewed journal article between the beginning of 2010 and June 2020 to capture the most recent available literature following the publication of a report on the health vulnerabilities due to climate change in Canada [10]. Citations that did not meet all of these criteria were excluded. We focused on weather and air pollution-related exposures, including extreme temperatures, wildfires, icy conditions, ambient air pollution, and others. Health impacts were considered through the lens of the WHO definition of health as "a state of complete physical, mental, and social wellbeing and not merely the absence of disease or infirmity" [27]. Older adults were defined as anyone 65 years and older. We applied the Statistics Canada definition of an immigrant as referring "to a person who is, or ever has been, a landed immigrant or permanent resident" [28]. Throughout the screening process, reviewers met to resolve conflicts related to study inclusion and exclusion.

2.4   CHARTING THE DATA

Articles that met the inclusion criteria were included in the scoping review results. An extraction form capturing the following data was developed: year of publication, study time-period, study location(s) and setting, study methodology, climatic and air pollution exposure variable(s) and assessment methods, health outcome(s), socioeconomic characteristic(s) studied, additional variables and interaction(s) explored, and whether sex/gender differences were considered in the study. Two independent reviewers (MT, LN) manually extracted half of the articles, each using this standardized form vetted by the research team. Three sample articles were jointly extracted to validate the form before continuing with the remaining articles independently.

2.5   COLLATING, SUMMARIZING, AND REPORTING THE RESULTS

Descriptive statistics were conducted in Stata® (Version 16) and Microsoft Excel® (2016) and data were narratively synthesized. The details of studies included in the review are presented in tables.

3   RESULTS

3.1   PROFILE OF STUDIES

A total of 2,543 citations were identified for screening, of which 257 full texts were reviewed. Fifty-two papers were included (Figure 2.1). Table 2.1 summarizes the key characteristics of the studies included in the review. The articles included data ranging from 1980 and 2015, with the longest study period covering 30 years. Populations in Ontario (25 of 52; 48%) and Quebec (20 of 52; 38%) were studied most frequently. The majority of studies in Ontario were population-based and covered all residents living in Ontario, differentiated by region and urban settings when possible. No studies investigating locations in Prince Edward Island, Yukon, Northwest Territories, or Nunavut the least populous regions, reported results on either older adult or immigrant populations. Figure 2 summarizes the locations of the included studies.

All of the studies used quantitative research methods. The most common study designs were ecological (15 of 52; 29%), cohort (14 of 52; 27%), or variations of case-control studies (12 of 52; 23%). The remaining publications included cross-sectional studies (3 of 52; 6%), panel studies (2 of 52; 4%),

non-randomized experimental studies (2 of 52; 4%), one randomized control trial, one case-only analysis, and one review.

Nearly all papers (51 of 52; 98%) examined age differences and reported results pertaining to older adults. Several articles included a measure of immigrant population density; however, only two papers presented health impacts in Canada's immigrant populations.

Most of the articles included air pollution and meteorological parameters broadly grouped based on the primary exposure of interest. One article was included in both categories because it reported on the health impacts of each as the primary exposure. Across all articles, the health impacts studied were: cardiovascular; respiratory; mortality; morbidity (i.e., emergency department visits); diabetes; cancer; fall-related injuries; neurological; mental health; renal; musculoskeletal; and ocular-related health outcomes.
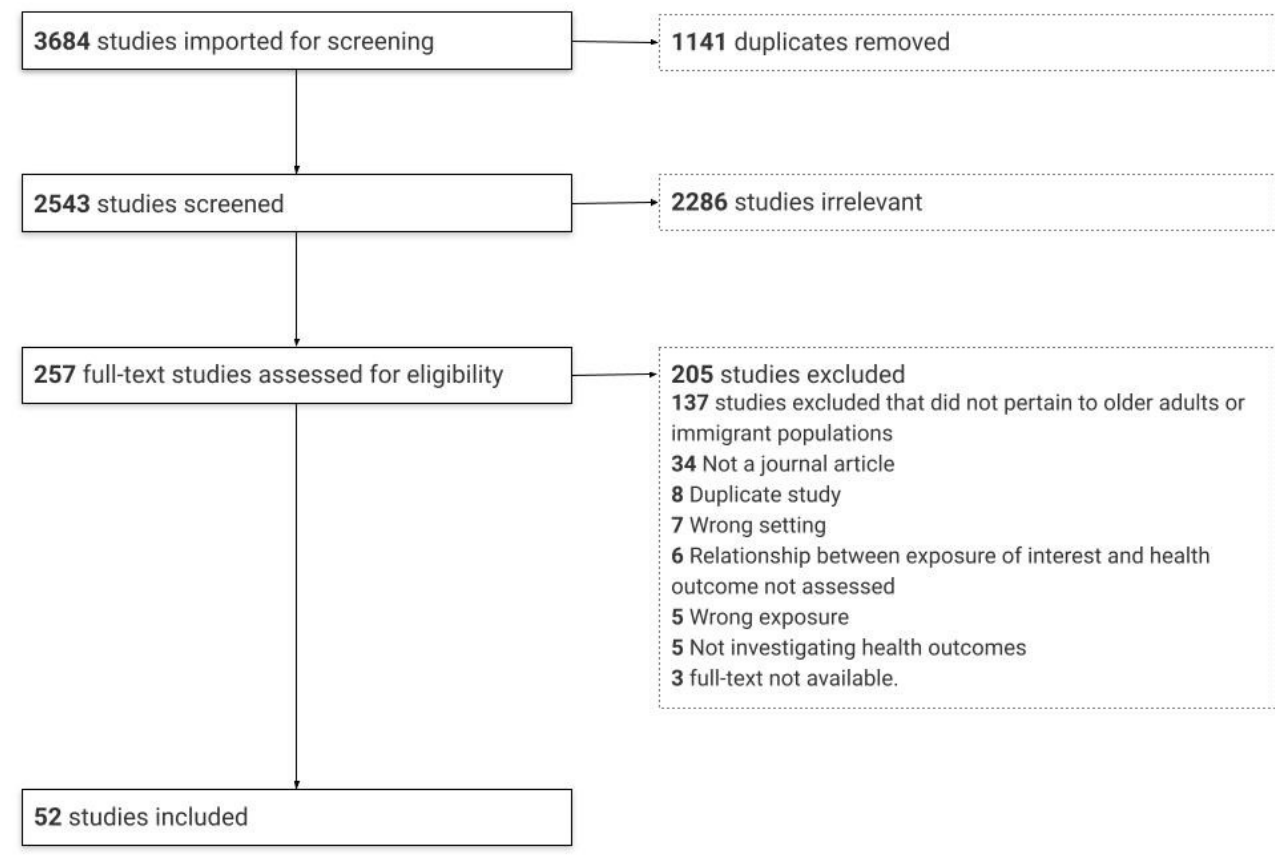
Figure 2.1 Flow diagram of study selection process.
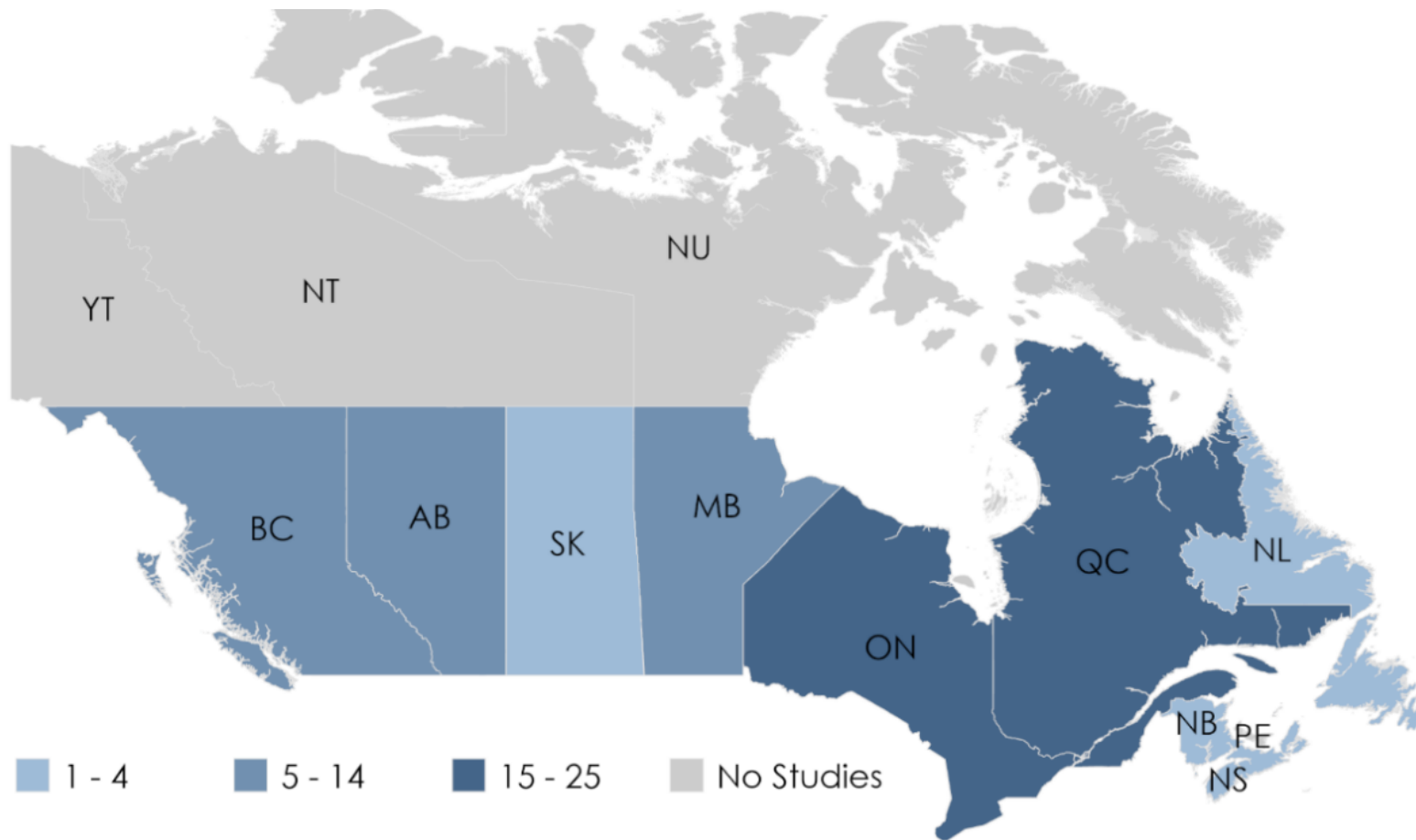
Figure 2.2 The frequency populations from each province were represented in the studies. A number of studies were specifically focused on populations in Ontario (20), Quebec (15), British Columbia (9), and Alberta (2), while the remaining studies included specific populations from multiple provinces.

Table 2.1 Climatic and air pollution variables and links to health in older adults and immigrant populations.

Authors	Population (n, age)	Primary exposure variables	Health impact category	Main findings
		Meteorological		
Vanasse 2017	112,793 participants; ≥65 years	Mean temperature	Cardiovascular	Decreasing temperature associated with increased risk in ≥65 years.
Bai 2018a	~13 million participants; <65 years vs ≥65 years	Mean, maximum, and extreme temperatures	Cardiovascular	Hot days associated with increased risk in ≥65 years.
Vida 2012	347,552 events; <65 years, ≥65 years	Mean temperature, diurnal temperature change	Mental health	Higher temperatures associated with increased risk in ≥65 years in an urban region.
Wang 2014	271,746 events; 0-14 years, 15-39 years, 50-59 years, ≥60 years	Minimum, maximum, mean temperature	Mental health	High temperatures associated with increased risk in ≥60 years.
Benmarhnia 2017	n NR <65 years vs. ≥65 years	Mean temperature	Mortality	Higher temperature associated with increased in ≥65 years.
Henderson 2013	~4.6 million participants; <75 years vs ≥75 years	Apparent maximum temperature (°C)	Mortality	Higher temperature associated with increased mortality in ≥75 years living in the coastal region.
Vutcovici 2014	Mean 30.1 (6.9 SD) deaths/day for 8,766 days; ≥65 years	Diurnal temperature change	Mortality	Increased diurnal temperature change associated with mortality.
Kosatsky 2012	398 participants; <65 years, 65-75 years, 75-85 years, ≥85	Heatwave	Mortality; cardiovascular; respiratory	Heatwaves associated with increased risk in 65-74 years.
Chen 2016	352,818 participants; <65 years vs ≥65 years	Mean temperature	Mortality; cardiovascular; respiratory; diabetes	Cold temperatures associated with increased cardiovascular mortality in ≥65 years.
Bustinza 2013	~6 million people; <65 years, 65-74 years, ≥75 years	Heatwave	Mortality; overall morbidity	Signficant increase in crude death rates for ≥75 years.
Burton 2015	NR	Flooding	Mortality; respiratory; mental health	Older adults at risk of adverse health events due to flooding.
Mondor 2015	136,323 participants; ≥65 years	Freezing rain, snowstorms	Fall-related injuries	Freezing rain associated with increased risk in ≥65 years.
Modarres 2012	1,077,813 participants; 40-74 years, ≥75 years	Minimum, maximum, mean temperature, precipitation, snow depth, daylight hours, air pressure	Fall-related injuries	Decreasing temperature, rainfall, daylight hours, and increased snow associated with increased risk in ≥75 years.
Modarres 2014	~900,000 participants; 40-74 years, ≥75 years	Minimum, maximum, mean temperature, precipitation, snow	Fall-related injuries	Maximum pressure and daylight hours associated with increased risk older adults. Rainfall depth was a predictor for older males.

		depth, daylight hours, air pressure		
Auger 2017	14,302 participants; <55 years, 55-64 years, 65-74 years, ≥75 years	Mean temperature	Ocular	Increased temperature associated with increased risk in 65-74 years.
Laverdière 2016	1,233 participants; 68-72 years, 73-77 years, 78-82 years	Daily maximum temperature ≥30°C	Overall morbidity	Hot days associated with increased risk.
Bélanger 2014*	3485 participants; 18-35 years, 35-44 years, 45-54 years, 55-64 years, ≥65 years	Hot and humid days	Overall morbidity	Increased prevalence in low income ≥65 years, decreased prevalence in foreign born residents.
Stapleton 2014	24 participants; 12 younger participants, mean 21 years (3 SD); 12 older participants, mean 65 years (5 SD)	Hot-dry and hot-humid conditions	Overall morbidity	Hot conditions associated with a significant increase in body heat content in older adults compared to younger.
Tajmir 2013	18 participants 10 younger; mean 26 (2.4 SD) years; 8 older; mean 68 (4.4 SD) years	Temperature categories; 23°C vs. 1°C	Overall morbidity	Cold conditions associated with greater impairment of manual movements in and reduced sensitivity.
McTavish 2018	227,135 participants Median 80 (74-85 IQR) years	Maximum temperature	Renal	High heat marginally associated with greater risk of acute kidney injury.
Ordon 2015	423,396 participants; 18-39 years, 40-49 years, 50-59 years, 60-69 years, >70 years	Minimum, maximum, mean temperature, extreme temperatures	Renal	Extreme heat associated with increased risk in 60-69 years.
Meteorological and Air pollution				
Krstic 2011	≥65 years	Steadman's apparent temperature, $PM_{2.5}$	Mortality; cardiovascular; respiratory	High and low temperatures associated with increased risk.
Air pollution				
Parent 2013*	1,772 participants; <60 years, 60-66 years, 67-71 years, >71 years	NO_2	Cancer	Increased risk in third quartile distribution of recent immigrants.
Goldberg 2018	788 participants; 50-70 years	UFP	Cancer	Positive but insignificant associations
Goldberg 2017	1,277 participants; Cases mean 62.23 years (SD NR), controls 61.03 years (SD NR)	NO_2, UFP	Cancer	Positive but insignificant associations
Chen 2014	5,229 participants; 25-44 years, 45-64 years, 65-74 years, 75-84 years, ≥85 years	AQHI, CO, NO_2, O_3, $PM_{2.5}$, PM_{10}, SO_2	Cardiovascular	AQHI, CO, and NO_2 associated with increased risk in ≥75 years.
Wang 2015	25,894 participants; <65 years vs ≥65 years	CO, NO_2, NO, O_3, $PM_{2.5}$	Cardiovascular	Observed positive associations with NO_2 and NO and negative associations with CO in ≥65 years.
Weichenthal 2017	2,881 events; <65 years vs ≥65 years	$PM_{2.5}$, NO_2, O_3	Cardiovascular	$PM_{2.5}$ associated with increased risk in ≥65 years.

Gan 2011	452,735 participants; <60 years, 60-69 years, ≥70 years	BC, NO, NO_2, $PM_{2.5}$	Cardiovascular	BC associated with increased risk of mortality in ≥60 years and hospitalizations in 60-69 years.
Shin 2019	5,071,956 participants; 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75-85 years	NO_2, O_3, O_x, $PM_{2.5}$	Cardiovascular	All pollutants were associated with increased risk of cardiovascular outcomes.
Bai 2019	50,062,146 and 5,141,172 participants; 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75-85 years;	$PM_{2.5}$, NO_2, O_3, O_x	Cardiovascular	All pollutants associated with increased risk in ≥65 years.
Shin 2018a	2,194,519 participants; <50 years, ≥50 years, ≥65 years	O_3	Cardiovascular	No significant associations ≥50 years.
Shin 2020	~19 million participants; 1-65 years vs >65 years	O_3	Cardiovascular	O_3 associated with increased risk in ≥65 years.
Stieb 2017	2013: 36 participants, 2014: 41 participants; 55-59 years, 60-64 years, 65-69 years, ≥70 years	AQHI, CO, NO_2, O_3, $PM_{2.5}$, SO_2	Cardiovascular	AQHI, $PM_{2.5}$, and O_3 associated with subclinical adverse cardio-respiratory effects.
Stieb 2018	2014: 36 participants, 2015: 34 participants; 55-59 years, 60-64 years, 65-69 years, ≥70 years	AQHI, CO, NO_2, O_3, O_x, $PM_{2.5}$, SO_2	Cardiovascular	AQHI, $PM_{2.5}$, O_3 and O_x associated with subclinical cardio-respiratory effects.
Stieb 2019	72 participants; 55-81 years	AQHI, CO, NO_2, O_3, $PM_{2.5}$	Cardiovascular	AQHI and $PM_{2.5}$ associated with subclinical cardio-respiratory effects and markers of oxidative stress.
Bai 2018b	Hypertension: 893,499 participants; Mean 48.6 (SD 14.3) years; Diabetes: 1,056,012 participants; Mean 51.1 (15.3 SD) years	UFP, NO_2	Cardiovascular; diabetes	UFP and NO_2 associated with diabetes and hypertension; NO_2 negatively associated with hypertension in 60-74 years.
Henderson 2011	281,711 participants; 0-5 years, 5-10 years, 10-20 years, 20-30 years, 30-40 years, 40-50 years, 50-60 years, 60-70 years, 70-80 years, ≥80 years	PM_{10}	Cardiovascular; respiratory	PM_{10} was associated with increased risk in 60-70 years and ≥80 years.
Crouse 2015	735,590 participants; 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, ≥75 years	NO_2	Cardiovascular; respiratory; diabetes; mortality	NO_2 associated with increased risk in 60-79 years.
Farhat 2013	~9.1 million participants; <75 years vs ≥75 years	O_3, $PM_{2.5}$	Cardiovascular; respiratory; mortality	O_3 and $PM_{2.5}$ were associated with increased risk in those ≥75 years.
Goldberg 2013	158,350 participants; ≥65 years	CO, NO_2, O_3, $PM_{2.5}$, SO_2	Mortality; cancer; cardiovascular; respiratory; diabetes	All pollutants associated with increased risk.
Vanos 2013	n NR	CO, NO_2, O_3, SO_2	Mortality	All pollutants associated with increased risk in ≥85 years.

	<65 years, 65-74 years, 75-84 years, ≥85 years			
de Roos 2014	678,361 participants; <65 years vs ≥65 years	Proximity to roads, BC, CO, NO, NO_2, O_3, $PM_{2.5}$, PM_{10}	Musculo-skeletal	O_3 associated with increased risk in ≥65 years.
Chen 2017a	2,066,639 participants; 55-64 years, 65-74 years, 75-85 years	NO_2, O_3, $PM_{2.5}$	Neurological	Closer proximity to roads, $PM_{2.5}$ and NO_2 associated with increased risk of dementia, $PM_{2.5}$ associated with increased risk of Parkinson's.
Chen 2017b	2,165,269 participants; Mean 66.8 (8.2 SD) years	NO_2, Proximity to roads, $PM_{2.5}$	Neurological	$PM_{2.5}$ and NO_2 associated with increased risk of dementia in those 55-85 years.
Shin 2018b	2,194,519 participants; 55-85 years	NO_2, O_3, $PM_{2.5}$	Neurological	$PM_{2.5}$ and O_3 associated with increased risk.
Neupane 2010	859 participants; ≥65 years	NO_2, $PM_{2.5}$, SO_2	Respiratory	NO_2 and $PM_{2.5}$ were associated with increased risk.
Szyszkowicz 2014	6,697 participants; 2-14 years, 15-39 years, 40-59 years, ≥60 years	AQHI, NO_2, O_3, $PM_{2.5}$	Respiratory	No significant associations in ≥60 years observed.
Lavigne 2012	3,728 participants; 2-14 years, 15-39 years, 40-59 years, ≥60 years	NO_2, CO, $PM_{2.5}$, SO_2	Respiratory	O_3 associated with increased risk during cold season in ≥60 years.
Gan 2013	467,994 participants; Mean 60 (11 SD) years	BC, NO, NO_2, $PM_{2.5}$	Respiratory	BC associated with increased risk in ≥65 years.
To 2013	~1.5 million participants; 0-4 years, 5-9 years, 10-19 years, 20-59 years, ≥60 years	AQHI, NO_2, O_3, $PM_{2.5}$	Respiratory	AQHI was associated with asthma in ≥60 years.
Ward 2015	107,108 participants; 0-19 years, 20-64 years, ≥65 years	AQI, CO, O_3, $PM_{2.5}$	Respiratory	No significant associations observed in ≥65 years.

*Reported results specific to immigrant populations. AQHI – Air Quality Health Index; AQI – Air Quality Index; BC – Black Carbon; UFP – Ultrafine particles (≤0.1 µm diameter)

3.2   Meteorological parameters

Twenty-two papers (22 of 52; 42%) examined health impacts due to meteorological parameters as primary exposures, including temperature, humidity, snow depth, and rainfall, and flooding, among others. The majority of these studies (12 of 22; 55%) were conducted in urban settings [29–40] or covered broader areas in Ontario [41–44], Quebec [45,46], and British Columbia [47] (7 of 22 (31%)), while two studies were conducted in lab settings [48,49]. In studies that involved wider geographic areas, authors generally controlled for the region of residence (i.e., urban or rural). One study was a review covering the health impacts of flooding in Canada [50].

3.2.1   Health impacts of meteorological parameters on older adults

Broad health impacts, such as non-accidental mortality or overall morbidity (i.e., total health-services use), made up nearly half of the publications, followed by cardiovascular outcomes, musculoskeletal, respiratory, mental, renal, ocular related health impacts, and diabetes. Evidence suggests older adults in Canada face health risks due to meteorological exposures, including weather temperature, precipitation-related variables, and flooding (Table 2.2). Still, results were not consistent in terms of whether they experience increased risk compared to other age groups.

Table 2.2 Summary of outcomes and associated meteorological parameters in older adults. An increase or decrease in the value of a temperature is denoted by ↑ or ↓, respectively

Outcome Category	Climate-related exposures
Mortality	↑ Temperature
	Diurnal temperature variation
	Heatwave
	Flooding
Overall Morbidity	↑ Temperature
	Heat waves
Cardiovascular	↑ Temperature
	Extreme heat
	Extreme cold
	Heatwave
Respiratory	↑ Temperature
	Heatwave
	Flooding
Fall-related injuries	↓ Temperature
	Precipitation
	Snow depth
	Daylight hours
	Air pressure

Mental Health	↑ Temperature
	↑Humidity
	Heatwave
	Flooding
Renal	↑ Temperature
	Heatwave
Ocular health	↑ Temperature
	Heatwave
Diabetes	Extreme heat *(null)*
	Extreme cold *(null)*

3.2.1.1 Mortality

Eight studies (7 of 22; 36%) reported results pertaining to the effects of temperature and heatwaves on non-accidental or all-cause mortality [30,31,38,40,42,46,47,50]. Mortality was associated with temperature in older adults [38,40,46], and in some studies, they exhibited higher levels of risk than younger age groups [30,31]. Benmarhnia et al. found temperature-mortality relationship differences by age was dependent on the contrast measure used, with a percentile method of comparison (i.e., 95th vs. 50th percentiles) proving more sensitive in detecting differences [30]. Within the older adult age stratum, it is not clear whether certain age subgroups of older adults experience greater risk to heat events, as sometimes "very old" (i.e., ≥75 years) subgroups demonstrated greater risk, while in other cases, "younger old" (i.e., 65-74 years) were at greater risk. One review found that while Canada tends to experience low flood-mortality rates overall, older adults may be at greater mortality risk [50].

3.2.1.2 Overall morbidity

Five studies (5 of 22; 24%) presented results on the effect of temperature on overall morbidity [32,46], perceived state of health during heat events [29], and other physiological measures of health [48,49]. One prospective cohort study of older adults found significant emergency department presentations and hospitalizations occurred more frequently when the daily maximum temperature was ≥ 30°C [32]. Yet, another study found that the prevalence of health impacts, measured as perceived overall state of health during "very hot and humid days," increased with advancing age only up until 65 years, after which it decreased [29]. Two non-randomized experimental studies found that older adults had more difficulty identifying ambient temperature decreases and did not perform as well as younger persons across a battery of tests, with heat posing a greater thermal challenge [48] and cold impairing dexterity and grip [49].

3.2.1.3 Cardiovascular health outcomes

Four studies (4 of 22; 18%) reported results on the effects of meteorological variables on cardiovascular-related health outcomes [36,40–42]. Extreme temperatures were associated with cardiovascular mortality [40,42], and heart failure [36,40,42]. Heat specifically was associated with cardiac arrest [42] and stroke in elderly individuals taking oral anticoagulants [41]. While Bai et al. found that acute myocardial infarction may be exclusively associated with cold temperatures, more moderate temperatures were responsible for a far greater burden of coronary heart disease and stroke hospitalizations [41]. Generally, there was little evidence for age effects.

3.2.1.4 Respiratory health outcomes

Three studies (3 of 22; 14%) reported results on the effects of meteorological exposures on respiratory health outcomes in older adults. In two studies, authors found that temperature was linked to respiratory mortality [40,42]; however, Krstic et al. suggest there was no strong evidence that those ≥65 years of age were at greater risk than other age groups [40]. Respiratory impacts related to flood exposures were also identified as a possible health hazard for older adults [50].

3.2.1.5 Fall-related injuries

Three studies (3 of 22; 14%) described the effect of meteorological variables on fall-related injuries [33–35]. Decreasing temperatures, and increased snow depth, and the number of snowy days appeared to be associated with increased hip fracture rates across all age groups [33,34], hours of daylight, atmospheric air pressure, and rainfall depth were important for older females with similar results for males, except for rainfall depth [33,34]. Another study found statistically significant increases in fall-related injuries among older adults following freezing rain warnings, except for hip fractures [35].

3.2.1.6 Mental health outcomes

Four studies (4 of 22; 18%) reported results on mental health impacts in older adults. Higher temperatures were significantly associated with mental and behavioral disorders in older adults. Wang et al. found greater effects in the elderly [39]. In contrast Bélanger et al. measured the perceived state of mental and physical health during heat events. They found the prevalence of poor mental and physical health was lower in older adults compared to younger ages [29]. A review identified older

adults as generally at greater risk from flooding, with mental illness as a potential health impact [50]. One study did not report any difference by age [37].

3.2.1.7   Renal health outcomes

Two studies (2 of 22; 9%) reported results on renal health impacts in older adults [43,44]. Increased heat exposure was associated with an increased risk of hospital admissions for acute kidney infection in older adults (IQR 74-85 years of age) [43] and emergency department visits for renal colic [44]. However, the latter association was stronger for those between the ages of 40-69 years.

3.2.1.8   Ocular health outcomes

The results of one study indicated that while acute exposure to elevated temperatures is associated with a higher likelihood of traction retinal detachment, the effect was stronger in those <75 years of age [45].

3.2.1.9   Diabetes

A single study investigated the effect of hot and cold temperatures on diabetes-related mortality, though the results were null [42].

3.2.2   Health impacts in immigrant populations

One cross-sectional survey study found that those born outside of Canada reported a lower prevalence of perceived physical and mental health impacts during very hot and humid days [29].

3.3   AIR POLLUTION

Most publications (31 of 52; 59%) included in this review examined health impacts due to air pollution as a primary exposure. Most were conducted in urban settings across Canada (21 of 31; 68%) or covered wider areas within Ontario [51–57], Alberta [58], or British Columbia [59] (9 of 31; 29%). Researchers generally controlled for the region of residence (i.e., urban or rural) when covering broader geographies. One panel study specifically focused on a rural population in Ontario [60].

3.3.1   Health impacts of air pollution in older adults

The relationship between air pollution and cardiovascular and respiratory health outcomes was most frequently studied in older adults. However, cancer, neurological health outcomes, diabetes,

mortality, and musculoskeletal health outcomes were also investigated (Table 3). Generally, air pollution had a deleterious impact on health but effects were somewhat specific to pollutants and outcomes.

Table 2.3 Summary of outcomes and associated air pollution exposures in older adults

Outcome Category	Air Pollution Exposures
Cardiovascular	AQHI, AQI, BC, CO, NO, NO_2, O_3, O_x, $PM_{2.5}$, PM_{10}, SO_2, UFP
Respiratory	AQHI, BC, CO, NO, NO_2, O_3, $PM_{2.5}$, PM_{10}, SO_2, UFP
Cancer	CO, NO_2, O_3, $PM_{2.5}$, SO_2, UFP
Neurological	NO_2, O_3, $PM_{2.5}$
Diabetes	CO, NO_2, O_3, $PM_{2.5}$, SO_2
Mortality	CO, NO_2, O_3, PM_{10}, SO_2
Musculoskeletal outcomes	Proximity to roads, BC, CO, NO, NO_2, O_3, $PM_{2.5}$, PM_{10}

3.3.1.1 Cardiovascular health outcomes

Thirteen studies (13 of 31; 42%) assessed the impact of air pollution on cardiovascular outcomes in older adults. The cardiovascular outcomes included total cardiovascular and circulatory mortality, atrial fibrillation, acute myocardial infarction, stroke [54,57,61,62], total cardiovascular morbidity [59], coronary heart disease [63], congestive heart failure [57], hypertension [64], and other subclinical cardiovascular measures [60,65,66]. Taken together, these sources indicate a relationship between air pollution and older adult cardiovascular health, but findings across older age groups were not always consistent and depended on the pollutant and condition of interest.

Total cardiovascular and circulatory mortality in older adults was associated with air pollutant exposure ($PM_{2.5}$ [67,68], CO, SO_2, NO_2 [68], and O_3 [67,69]), except for one cohort study [68]. Regarding the effect of age, evidence was mixed, with some research reporting higher levels of risk among older adults relative to younger age groups and others reporting little effect by age.

Atrial fibrillation and related acute cardiovascular events, such as acute myocardial infarction (AMI) and stroke incidence in older adults, were also linked to $PM_{2.5}$ [54,57,62], NO_2 [54,58] O_3, and redox-weighted averages of NO_2 and O_3 (O_x) exposure [54,57]. While not consistent across all studies, greater effect sizes in older adults were generally observed for $PM_{2.5}$ exposure and AMI [57], especially in those with hypertension [62]. Findings were similar for O_3 and O_x exposure and stroke [54]. Likewise, the Air Quality Health Index (AQHI) demonstrated a stronger association with acute ischemic stroke in older seniors [61].

Relationships were observed between air pollution and cardiovascular morbidity. For example, wildfire smoke exposure, assessed via PM_{10}, was linked to total cardiovascular morbidity in those between ages 40-50 years and those ≥ 80 years [59]. Exposure to $PM_{2.5}$, NO_2, O_3, and O_x was positively associated with congestive heart failure (CHF) incidenc in older adults [57] and ultrafine particles (<0.1μm in diameter) (UFP) and NO_2 were associated with hypertension [64]. In both cases, effect sizes were smaller in older ages compared to younger ages. The AQHI was also associated with sub-clinical adverse cardiorespiratory effects in those over 55 years of age [60,65]. Conversely, a randomized controlled trial found no consistent associations between air pollution and daily cardiovascular measures in older adults aged 55-81 [70]. No age differences were likewise observed for associations between coronary heart disease (CHD) morbidity and black carbon exposure [63].

3.3.1.2   Respiratory health outcomes

Eleven studies (11 of 31; 35%) investigated the effects of air pollution on respiratory health outcomes in older populations. These publications examined general respiratory mortality [40,67,68,71] and morbidity [56,59], COPD mortality and morbidity [72], asthma [55,59,73,74], and pneumonia [75]. All but three of these studies [56,73,74] found air pollution associated with older adult respiratory health; however, results were not clear about whether older adults were at greater risk of adverse respiratory health outcomes than populations under the age of 65.

While O_3, $PM_{2.5}$, black carbon, and NO_2 have been linked to respiratory mortality across populations in Canada, stratification by age generally revealed that when associations were observed, they tended to be weaker for older ages compared to populations under the age of 65 [40,67,68,71,72]. In one study, significant estimates between $PM_{2.5}$ and respiratory mortality were observed in those ≥75 years of age [67]. Results were similar in terms of total respiratory morbidity [56], COPD [72], and acute bronchitis and upper respiratory infection diagnoses [59]. One case-control study including only those ≥65 years of age, also found long-term exposure to increased levels of NO_2 and $PM_{2.5}$ were independently associated with pneumonia hospitalization [75].

Likewise, PM_{10}, $PM_{2.5}$, SO_2, O_3, and the Air Quality Health Index were associated with asthma morbidity across populations but not always observed in older age groups. The level of risk in older adults often depended on the specific age subgroup [59,73,74]. For example, associations with PM_{10} were observed for those between the ages of 60-70 years but not those 70-80 [59], while another study found those ≥60 years of age generally had greater risk ratios than adults under the age of 65 years [55].

3.3.1.3   Cancer

Four studies (4 of 31; 13%) assessed the effects of air pollution on cancer [68,76–78]. Articles generally assessed older populations and found that air pollutants, including UFP, NO_2, SO_2, and O_3, increased the risk of certain cancers. Exposure to NO_2 [77] and UFP [76,77] showed positive, albeit insignificant, associations with incident postmenopausal breast cancer in older women and strong positive associations were observed between NO_2, O_3, and SO_2 and cancer mortality in older adults (18). While significant associations were found between NO_2 and incident prostate cancer in men, minimal age differences were observed [78].

3.3.1.4   Neurological health outcomes

Three studies (3 of 31; 10%) investigated the impacts of air pollution on Parkinson's disease (PD) and dementia [51–53]. Air pollution appears to have a negative impact on the neurological health of older adults; however, results were varied as to which pollutants pose a risk. In terms of incident PD, studies found significant associations with $PM_{2.5}$ [51,53] and O_3 [53]; however, there were conflicting results with respect to NO_2 [51,53]. Dementia was associated with exposure to $PM_{2.5}$ and NO_2 [51,52], but not O_3 [52].

3.3.1.5   Diabetes

Two studies (2 of 31; 6%) investigated the effects of air pollution and diabetes [64,68]. Studies found $PM_{2.5}$, NO_2, CO, and SO_2 were associated with mortality in older adults [68] and UFP particles and NO_2 with diabetes morbidity [64]. In terms of morbidity, effect sizes in older adults were smaller compared to younger age groups.

3.3.1.6   Mortality

Four studies (4 of 31; 13%) investigated the effects of air pollution on non-accidental mortality in several provinces [67,68,71,79]. Associations were observed between $PM_{2.5}$ [67,68], NO_2 [68,71,79], O_3 [67,79], SO_2, and CO [68,79] and non-accidental mortality, however, age effects were not consistent. While somewhat pollutant-dependent, older adults generally exhibited an increased risk of mortality with air pollution exposure, but this risk was not necessarily greater than other age groups.

3.3.1.7   Musculoskeletal outcomes

A single study assessed the effects of air pollution on rheumatoid arthritis (RA) [80]. While the authors observed that RA was associated with proximity to traffic, neither traffic-related air pollution (TRAP) nor noise was responsible for the associations, which were stronger for those <65 years of age.

3.3.2   Health impacts in immigrant populations

One Montreal-based study investigated the effects of air pollution on health in immigrant populations. Parent et al. found that exposure to NO_2, as a measure of TRAP, was associated with an increased risk of incident prostate cancer. Risks were higher amongst men in the third quartile distribution of recent immigrants [78].

3.4   FACTORS INFLUENCING THE CLIMATE AND AIR POLLUTION-HEALTH RELATIONSHIP

Sociodemographic, socioeconomic, and environmental factors may also modify air pollution and meteorological impacts on older adult health. Some studies did explicitly explore the intersection of these factors in older adults (e.g., lower-income older adults). Sociodemographic variables included sex and the proportion of immigrants in a neighborhood. Socioeconomic indicators included measures of income, education, and employment. Environmental variables included seasonality, region of residence (i.e., urban vs. rural), and population density. Comorbidities were frequently an important factor concerning the health impacts of climate and air pollution exposures in older adults.

3.4.1   Sociodemographic characteristics

Sex and the proportion of immigrants per neighborhood were the variables most commonly adjusted for in analyses. Over half of the studies explored sex differences, but the results were varied. Sex differences were observed more frequently when assessing the effects of meteorological parameters, including heat and precipitation, on health. However, one sex was not consistently at higher risk than the other across studies. Generally, differences in risk by sex depended on specific exposures. The proportion of immigrants in neighborhoods was adjusted for in several air pollution studies, though rarely in meteorological studies.

Other sociodemographic characteristics, including visible minority status, ethnicity, and marital status, in addition to comorbidity and behavioral factors, appeared to influence health risks from environmental exposures. Laverdière et al. found that high social participation in older adults was

strongly protective in relation to adverse heat-related events. At the same time, disability or requiring assistance for daily living activities was a risk factor [32].

3.4.2 Socioeconomic characteristics

Indicators of socioeconomic status (SES) were frequently considered in studies where air pollution was the primary exposure (16 of 31; 52%), compared to a smaller number of meteorologically-focused studies (7 of 22; 32%). The most common variables used to account for SES were income, education, and employment. While most studies adjusted for these factors, a number of those that stratified according to SES reported that lower-income, less-than high school diploma education and unemployment rates were associated with higher levels of risk for adverse health outcomes, especially with respect to air pollution. Low income was the main indicator of SES and a predictor of adverse health outcomes with meteorological exposures. Indicators were often at the neighborhood-level, rather than the individual level. Some studies noted little effect or confounding by SES in terms of air pollution, and in one study, high SES was associated with increased cardiovascular hospitalization [63].

3.4.3 Environmental characteristics

A number of studies adjusted for seasonality as an important covariate in terms of the effect of both air pollution and meteorological factors; however, interactions between seasonality and these exposures were studied less frequently. Similarly, authors found the risk of mortality in older adults due to air pollution appeared to be modified by different large-scale weather systems (synoptic weather type) [79]. Place of residence at both regional and local scales also influenced the effect of meteorological and air pollution exposures on health. For example, stronger associations between climatic and air pollution exposures and adverse health impacts were observed for those living in urban areas compared to rural [51,53]. Some research also observed within-city variation [67,71]. Evidence also suggests population density may be relevant to health risk in older adults [31,47]. Henderson et al. found that the effect of temperature was markedly higher for those aged <75 years in three of four ecologically distinct geographical areas in British Colombia, except for the most densely populated coastal region [47].

4   DISCUSSION

In the rapidly shifting Canadian climate [81] with an ageing population [11] and continued migration [12], we found that older adult health is at risk due to extreme weather, increasing temperatures, and air pollution. However, we identified a gap in our knowledge of how these exposures impact immigrant health. Furthermore, not all areas across Canada have been investigated to the same extent with people residing the Prairies, Maritimes, and Territories being studied less than the more populous Ontario and Quebec, if at all.

4.1   EVIDENCE FOR OLDER ADULT HEALTH RISK DUE TO CLIMATE- AND AIR POLLUTION-RELATED EXPOSURES IN CANADA

Several studies investigated climate- and air pollution-related health risks in older people living in Canada. There is compelling evidence that older adult health is adversely affected by these exposures. Specifically, older adults were at risk of cardiovascular, respiratory, mortality and overall morbidity outcomes due to meteorological and air pollution exposures. Relationships with musculoskeletal, mental health, renal, and ocular health impacts were only observed for meteorological exposures, and cancer, neurological disorders, and diabetes impacts were only observed for air pollution in older adults. It is worth noting that the health burden of these exposures may be underestimated since the frequent use of mortality and forms of acute care as measures of health tend to capture more severe health impacts.

Significant associations among older adults were typically observed for specific exposures and conditions (e.g., O_3 and stroke), which differed by age group. In terms of the impact of PM_{10} on respiratory health, for instance, significant associations were only detected among those between 60 and 70 years of age but not among older age strata [55], and similar results were observed for some meteorological parameters. These findings support that climate and air pollution stressors overall pose a risk to older adults' mental and physical health in Canada are consistent with several other works focused on higher-income countries [18,82–85].

The integrative review by Leyva et al. identified that older adults do not necessarily perceive themselves to be suffering a greater risk of health impacts. However, they bear a disproportionate burden of health impacts due to climate stressors [18]. Likewise, we found that older adults tended to

face greater health risks from heat effects. Experimental studies identified they had more difficulty identifying temperature changes and performed poorer tests in both heat and cold conditions than younger people [48,86]. However, those ≥65 years of age experienced a decreased prevalence of *perceived* health impacts during "very hot and humid days" compared to those under 65 [29].

The differences in health effects between older and younger persons in Canada is unclear. Over a third of research that looked at different age groups reported stronger associations in older adults than in younger adults [30,34,39,48,50,55,58,61,62,67,79,86] while others did not [37,42,45,46,69,72,80]. Many articles reported mixed results depending on specific outcomes and contextual factors. While many of the effects of climate change and air pollution are not restricted to older adults, factors like limited mobility and pre-existing medical conditions can render them more severe [85]. Future work focused on this question could help to establish how older adults differ from younger adults within this context.

All of the studies included in this review employed quantitative methods and were predominantly epidemiological. While epidemiological studies are necessary for quantifying the risk posed, qualitative methods can provide valuable information for health interventions since they offer further in-depth knowledge and perspectives regarding the experience of resiliency to climate and air pollution stressors for different populations.

4.2   ONE SIZE DOES NOT FIT ALL: CONTEXTUAL FACTORS INFLUENCING OLDER ADULT HEALTH RISK

Contextual variation is critical in understanding the distribution of adverse health impacts due to climate- and air pollution-related exposures. The effects on older adult health in Canada depend on the intersection of multiple factors. Shin et al. reported higher risks of circulatory mortality from O_3 in females over 65 years of age than males and younger females [69]. Additionally, comorbidities and low SES in older people often increased the risk of adverse health events. Region of residence also affected the vulnerability of older adults. A study in British Columbia found that older adults living in coastal areas of higher population density were more susceptible to adverse effects of extreme heat exposure, while in inland regions with lower population densities, very few effects varied by age [47]. The authors also suggested that further understanding of the mechanisms underlying varying sex-based health impacts would be essential [29]. Resilience to climate stressors does not depend on a single or even a few factors alone but complex interactions of factors. Improving our understanding of how contextual factors interact to reduce or promote resilience through exposure and sensitivity, spanning from the

individual to the societal level, will enable effective strategies to meet the needs of older adults in our changing climate.

Fewer studies focused on social and behavioral factors that promote or reduce resilience to climatic and air pollution exposures in older adults; despite that, they are important determinants to consider. For example, different time-activity patterns between age strata may lead to differential exposures [29,41,57]. While this may influence our ability to detect age differences, it may also point to existing resiliency in these populations in Canada. In addition, Laverdière et al. identified that high social participation in older adults was strongly protective concerning adverse heat-related events. At the same time, low autonomy and poor health status were risk factors [32]. Promoting social participation among older adults through age-friendly cities, which aim to foster community engagement and active living environments, could be an effective strategy to reach isolated older people and prevent adverse health outcomes. Further qualitative and quantitative studies can refine our knowledge of social and behavioral indicators of risk and resiliency in older populations will help build resilience and promote the health of these people.

4.3   MISSING KNOWLEDGE OF THE HEALTH RISK FACING IMMIGRANT COMMUNITIES IN CANADA

In 2016, 21.9% of the Canadian population identified themselves as foreign-born [13]. Yet, there was very little literature concerning climate- and air pollution-related health impacts in immigrant populations in Canada available, reflecting a critical knowledge gap in the field. Furthermore, there was none reporting on the impacts on older immigrants.

Immigrants in Canada are a heterogeneous group, and it is important to consider this diversity and differentiate risk and drivers of risk and resilience across sub-groups in future work. Immigrant populations may face barriers linked to language, socioeconomic status, access to healthcare, and have tendencies to settle in urban centers, which could affect resilience in these communities. The *healthy immigrant effect* diminishes with time, and older immigrants have more chronic conditions, which could exacerbate health impacts related to climate and air pollution [19,20,22]. Some research suggests that older immigrant women's healthcare needs and concerns, specifically, are not being met by the healthcare system [87]. Moreover, immigrants who are racialized face different challenges than those who are non-racialized. For example, in those of prime work age (25-54 years), racialized immigrant men and women earn 71 and 79 cents, respectively, for one dollar that non-racialized immigrant men and women earn [88].

4.4 Geographical gaps in the literature

There are substantial gaps in terms of the location of populations that have been studied. The impact of climatic and air pollution variables on health was studied most frequently in southern Ontario and Quebec where the majority of the Canadian population resides. Several studies also focused on residents of British Colombia, mostly in urban centers. The Prairie and Maritimes provinces were largely understudied, with urban populations in Alberta being studied the most frequently within this group. No studies in the Territories were found, despite the fact that these northern regions are facing greater impacts from climate change [81]. The distribution in geographical coverage could be influenced by variation in air pollution concentrations across Canada. Generally, urban areas in southern Ontario, Alberta, and British Columbia experience higher levels of $PM_{2.5}$, O_3, and NO_2 relative other regions [6]. There are also regions in British Columbia and Alberta that experience greater $PM_{2.5}$ exposure in areas where summer wildfires are more frequent [6].

Variations in climate adaptation and mitigation policy between regions may also reflect research priorities and provide some explanation for geographical gaps. The Prairie Provinces, for example, have little to no climate policy in place and have reported increased emissions from 2005 to 2019 compared to Ontario and Quebec where there is at least some leadership in climate policy and have reported decreased emissions [89].

Most publications were also set in urban areas, though some province-wide population studies included urban and rural residence indicators. Generally, those living in urban areas were at greater risk for air pollution and extreme temperatures, which is consistent with other work highlighting the Urban Heat Island (UHI) effect [90]. The UHI describes the higher average temperatures experienced by urban areas relative to nearby non-urban areas resulting from several factors, including density, land-use and travel proximity, and decreased green spaces, among others. However, the health impacts of climate change in rural populations and the specific factors that influence this relationship in Canada are largely undetermined for older adults and immigrants.

Climate impacts can differ depending on the provincial and territorial weather patterns and geographies and provincial policies. At the same time, there are significant variations in contextual factors within Canada in terms of regional policy, population densities, demographics, and community characteristics. Capturing some of these important contextual factors for populations living across Canada can help identify where and which people are at greater risk for poorer health outcomes.

Consequently, these understudied regions represent an important research gap in Canadian environmental health literature and warrant further investigation.

4.5 LIMITATIONS

There are limitations in this scoping review. Although the search strategy was intended to be comprehensive and included an extensive range of keywords, some papers may have been missed if the titles or keywords did not correspond with search parameters. In some cases there were few studies on certain outcomes which prevented a true synthesis. We also did not endeavor to assess the quality of evidence included in this review. The heterogeneity of exposure assessment, study design, and large number of health outcomes limits our ability to draw conclusions about the level of risk older adult's face with respect to climatic and air pollution exposures. We also focused on a limited geographic area, limiting the generalizability of our findings to Canada.

5 CONCLUSIONS AND NEXT STEPS

The literature studied for this review indicated that older people living in Canada experience increased health risks due to climate- and air pollution-related exposures, and are influenced by other intersecting determinants. However, further studies are required to elucidate how these exposures intersect among themselves and other participating determinants to promote or reduce resiliency in this population. As little currently exists, more research about the health impacts of climate change and air pollution on immigrant populations is necessary, in addition to further studies on the health impacts on older adults and immigrants in understudied Canadian geographies, including the Prairies, Maritimes, and northern territories. The next steps could involve investigating other populations in Canada facing greater risk to climate change and air pollution.

ACKNOWLEDGEMENTS

SUPPLEMENTARY MATERIALS

The scoping review protocol and detailed search string (Table A1) are available in Appendix 1.

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Chapter 3: Exploring community-level health impacts of exposure to climate- and air pollution-related hazards in older adult and immigrant populations living in Edmonton, AB.

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ABSTRACT

Investigating health risks associated with climate- and air pollution-related hazards in Edmonton, AB will provide insights into the resilience of older adults and immigrants at the community level. Higher proportions of older adults associated with increased rates of cardiovascular, injury, mental, and respiratory health events at the dissemination area (DA) level ((Prevalence Rate Ratio (PRR) [95%CI] = 1.051 [1.044, 1.058]; 1.041 [1.037, 1.045]; 1.027 [1.021, 1.033]; 1.022 [1.018, 1.027]). Rates of injuries and respiratory events increased with increasing proportions of refugees (PRR [95%CI] = 1.007 [1.001, 1.013]; 1.017 [1.011, 1.024]). Conversely, higher proportions of economic immigrants demonstrated protective effects for cardiovascular, injury, and mental health events (PRR=0.990 [0.985, 0.996]; 0.993 [0.989, 0.996]; 0.984 [0.979, 0.989]). Associations between climate change and air pollution hazards were dependent upon the type of health event. The effects of certain hazards depended on the proportions of immigrants and older adults in a DA (heat effect on injury rates: PRR [95%CI] = 0.865 [0.809, 0.925] at 5% ≥65 years; 1.110 [1.011, 1.219] at 25% ≥65 years). Future work should focus on human health within the communities and environments that will be disproportionately affected to address the community-level vulnerability.

1 INTRODUCTION

1.1 HEALTH RISK OF CLIMATE CHANGE AND AIR POLLUTION ON OLDER ADULTS AND IMMIGRANTS

Climate change and air pollution are two closely related environmental phenomena that pose a significant threat to public health. Furthermore, the health of some populations – such as older adults and immigrants – can be disproportionately affected by environmental hazards associated with climate change and air pollution (e.g., increasing temperatures, extreme events, poor air quality) [1–4]. The limited coping capacity of older adults may be related to several issues. Some older adults, for example, may face challenges ranging from physiological changes and multi-morbidity at the individual level to social isolation and inadequate access to health and welfare services at community levels [5–10]. The immigrant population in Canada has been increasing over the past 25 years, and currently, one in five of those in Canada identified as immigrants [11,12]. While immigrants may arrive healthier than their Canada-born counterparts, this 'healthy immigrant' effect diminishes with time [13]. Immigrant populations may also face barriers with respect to socioeconomic differences, living arrangements, cultural and/or language barriers, and racism that could exacerbate the risk of exposure to climate and air pollution hazards on their health [13–17]. It is important to consider the diversity within the immigrant population and differentiate risk and drivers of risk and resilience across sub-groups [18].

The Prairie Provinces in Canada are currently experiencing, and at risk for, further changes in occurrences of extreme temperatures, weather events, air pollution, drought, and wildfires [19]. With estimates of life expectancy continually increasing, an aging baby-boom generation [11], rising levels of immigration to metropolitan centers, and potential climate migration [12], it is critical to understand what promotes or reduces resilience to adverse health outcomes within this context. However, this knowledge is largely missing for Edmonton and Alberta as a whole. Initiatives that consider at-risk populations, like older adults and immigrants, and are informed by local context may be better positioned to effectively reduce adverse health impacts both now and in the future as our climate continues to change.

1.2 CONCEPTUAL FRAMEWORK

The conceptual framework for this study was adapted from the Intergovernmental Panel on Climate Change Fifth Assessment (IPCC AR5) risk framework (Figure 3.1), which includes three dimensions

characterizing the risk of an impact; the hazard itself, the degree of exposure to the hazard, and the inherent vulnerability of the system [20]. **Hazard** refers to 'the occurrence of a natural or human-induced physical event or trend' that has the potential to cause an adverse impact [20]. **Exposure** 'imparts a spatial connotation' in that it refers to the presence of a system (e.g., people, species or ecosystems, economic, social or cultural assets, etc.) at a location where a hazard occurs [21]. Through quantifying the spatial distribution of various climate- and air pollution-related hazards, the dimensions of hazard and exposure are captured in this study.

Vulnerability refers to the 'predisposition of a system to be adversely affected' [20] and is a characteristic property of a system. This predisposition is defined by components of sensitivity (factors that increase vulnerability) and adaptive capacity (factors that decrease vulnerability) that together show a system's internal state [20]. In this study, this dimension is explored by examining a number of community-level factors as potential indicators of sensitivity and adaptive capacity to characterize community-level vulnerability to adverse health impacts.

This study aims to explore and characterize health risk and resilience with respect to older adult and immigrant communities at a local scale. The results from this epidemiological study can help to inform robust and actionable risk assessments and adaptation initiatives. Additionally, these results will assist in developing an Edmonton-based mapping index for monitoring and protecting health in these equity-seeking populations.
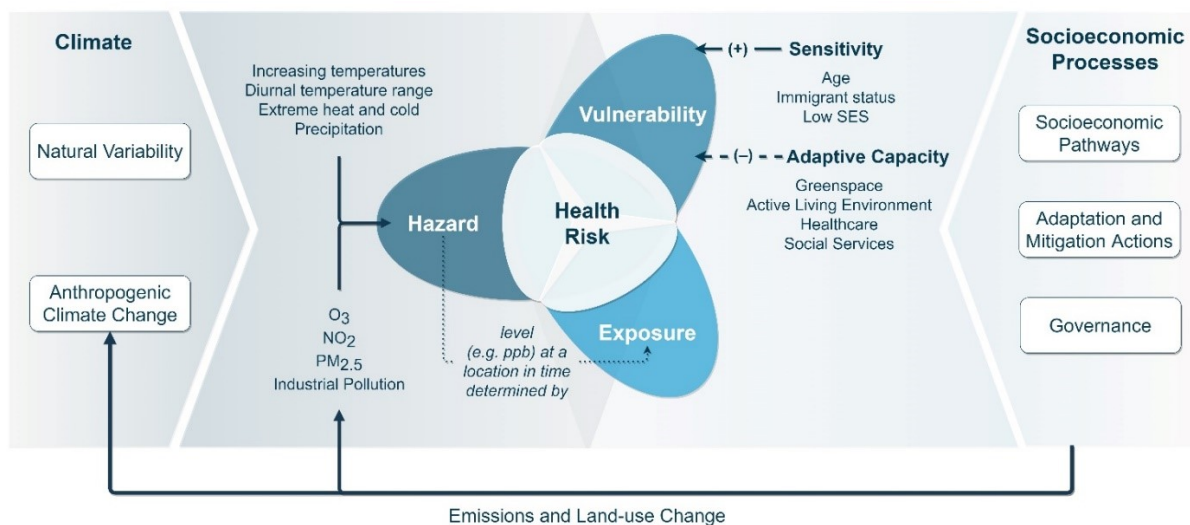
Figure 3.1 Conceptual framework for assessing health risk due to climate change and air pollution hazards, adapted from the IPCC AR5 WGII risk-assessment framework *[20]*.

2 METHODS

2.1 STUDY DESIGN, LOCATION, AND POPULATION

This ecological correlation study was conducted at the level of the dissemination area (DA). On average, DAs represent 400-700 people and are the smallest standard geographic area for which all census data are disseminated across Canada (Figure 3.2). Using aggregate data at this level, we explored geographical relationships between per capita rates of health events and climate- and air pollution-related hazards and indicators of community vulnerability. The number of cardiovascular, injury, mental, and respiratory health events occurring between January 1, 2015 and December 31, 2018 per dissemination area were determined for 1,126 of 1,196 DAs in Edmonton, AB. We focused analyses on the proportions of older adults and immigrants per DA to characterize health risk and resilience with respect to older adult and immigrant communities.

Edmonton was home to 932,546 residents in 2016, and the average age was 37.8 years [22]. Older adults (≥65 years) comprised 12.1% of those living in Edmonton, a share that is expected to approach 20% by 2046 [22]). Just under a third (30%) of residents were immigrants and refugees [23]. While the 2019 SARS-CoV-2 pandemic may have suppressed international migration temporarily, immigration is still expected to be the primary driver of population growth in Alberta [22].

Situated on the North Saskatchewan River over approximately 700 km^2 of land area, Edmonton has a humid continental climate [24] with average daily temperatures ranging from -10.4^{o}C in January to 17.7^{o}C in July [25]. Local air quality in this metropolitan center is also impacted by the presence of major petrochemical industrial activities and wildfire events occurring in Alberta and surrounding provinces. Relative to some other areas of the province, Edmonton experiences elevated ambient concentrations of pollutants, including fine particulate matter ($PM_{2.5}$), ozone (O_3), and nitrogen dioxide (NO_2) [26].
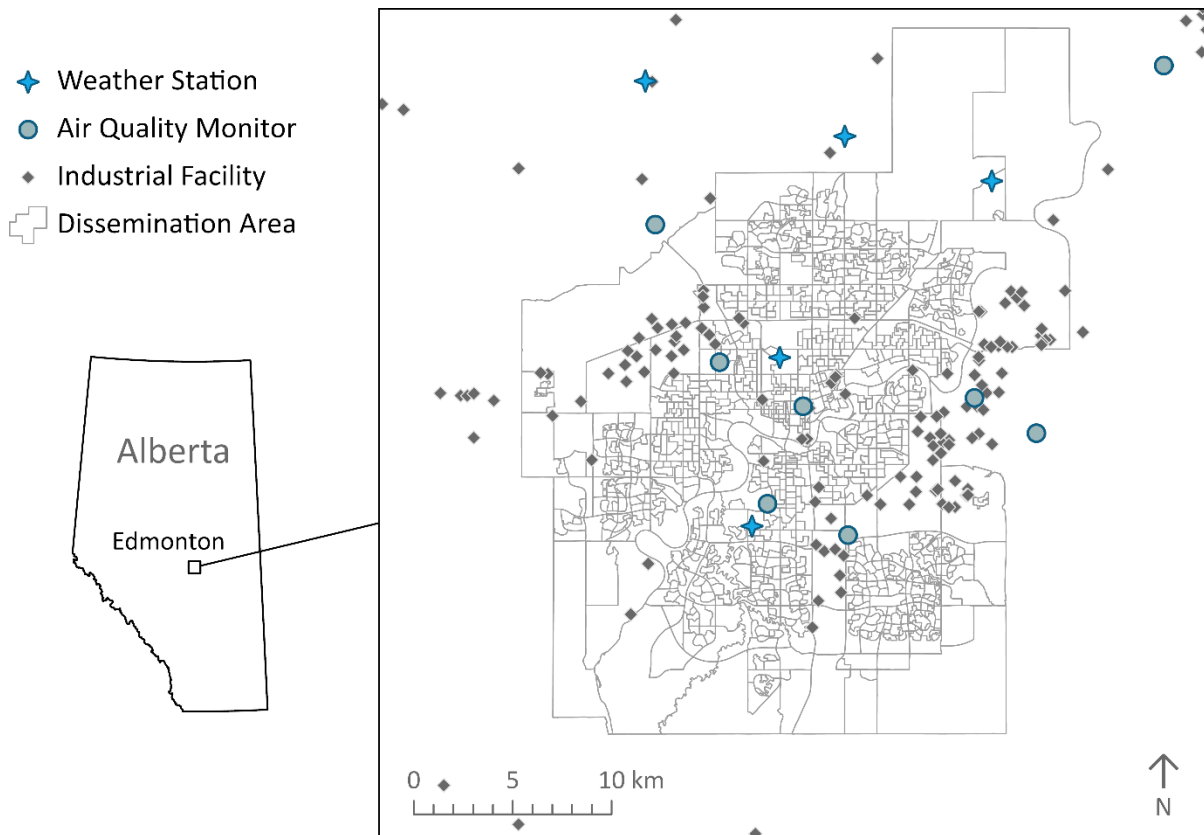
Figure 3.2. Map of Edmonton, Alberta by dissemination area (DA) with the locations of nearby weather stations, air quality monitors, and industrial facilities (Nielsen, C.C.). More stations located further away from city limits were also included in the analyses.

2.2 HEALTH OUTCOMES

The outcome of interest in this study was defined as the per capita rate of adverse health events (hospital, clinic, and physician visits) which were captured by healthcare service use. Since the overall health burden at the community level was of primary interest, events over the four-year study period were aggregated to the DA level using postal codes. A single person may have contributed multiple events within a DA. Cardiovascular, injury, mental, and respiratory health events were selected as climate-sensitive outcome categories, according to a recent review [18]. **Cardiovascular events** included atrial fibrillation, chronic heart disease, myocardial infarction, stroke, and transient ischemic attack. **Injuries** included fall-related injuries, spinal cord injuries, and traumatic brain injuries. **Mental health** events included anxiety, depression, post-traumatic stress disorder (PTSD), and stress. **Respiratory events** included acute bronchitis, acute respiratory disease, asthma, bronchiolitis, chronic obstructive pulmonary disease (COPD), chronic rhinosinusitis and allergic rhinitis, pneumonia, and shortness of breath and wheeze (Table A3).

Data on health events were obtained from two health administrative databases. The Canadian Institute for Health Information (CIHI) discharge abstract database (DAD) captures data for hospital inpatient discharges. The National Ambulatory Care Reporting System (NACRS) captures data on health service use related to the emergency department, day surgery, outpatient and community-based clinics, rehabilitation facilities, outpatient mental health, and diagnostic imaging services. In Alberta, reporting to these databases is mandated, so all facilities are captured in these databases. The International Classification of Diseases 9th (ICD-9) and 10th (ICD-10) revisions were used to identify adverse health events, including those related to chronic conditions, occurring between January 1, 2015, and December 31, 2018, among Edmonton residents with healthcare numbers. Data were identified using ICD-10 codes, except for events reported in physician billing, which is coded using ICD-9 codes (Table A3). Previously published algorithms and general equivalence mappings were used to match outcomes between ICD revisions [27–30].

To address our objective and explore the community-level health impacts of climate- and air pollution-related hazards across DAs in Edmonton, postal codes, date of admission, and information on age categories were also acquired. Further detailed data on sex and age (>65, >75, >85) were also examined for community-dwelling older adults.

2.3 CLIMATE AND AIR POLLUTION HAZARD EXPOSURE

2.3.1 Climate-related hazards

Meteorological datasets from the Canadian Urban Environmental Health Research Consortium (CANUE) included metrics for **annual average minimum**, **maximum,** and **mean temperatures**, **diurnal temperature range**, **annual total precipitation as rain and snow**, and the **number of heat events** for Edmonton by DA [31,32]. Despite being limited to 2015, these data were used because exposures covering the entire study period using different methods proved less robust (Table A4.1).

Average daily temperature data were obtained from Alberta Climate Information Service [33] to calculate two additional measures capturing heat and one capturing cold exposure. The number of days where the maximum temperature was >29°C and the minimum temperature was >14°C were calculated, based on the daily temperatures used by Environment Canada for **heat warnings** in Edmonton [34]. The **number of days over** and **under 12.8°C**, the temperature at which the lowest mortality in Edmonton occurs (*minimum mortality temperature*), were also calculated [35]. Three

weather stations were within city limits, but data from 14 surrounding stations were included to improve accuracy in spatial interpolation. Exposure levels for each measure were interpolated from weather stations using inverse distance weighting and extracted to DA centroids by a geographer.

2.3.2   Seasonality

Analyses were stratified for seasonality by calculating the proportion of health events occurring in the warm season (April-September) in each DA. Proportions above 50% indicate that more health events occurred in the warm season, while proportions below 50% indicate more health events in the cold season (October-March).

2.3.3   Air pollution-related hazards

Three common criteria air pollutants were included in our analysis: ozone (O_3), fine particulate matter ($PM_{2.5}$), and nitrogen dioxide (NO_2). There were few stationary air pollution monitors available in Edmonton, so data from these sources were limited. Instead, data estimated using land-use regression models (LUR) for the most recent available years capturing annual average concentrations of $PM_{2.5}$ ($\mu g/m^3$) (2015-18) [32,36], NO_2 (ppb) (2015-16) [32,37,38], and O_3 (ppb) (2015) [39,40] were obtained from the CANUE health research consortium. More information about the LUR models used in this analysis is available in Appendix 4. Data on industrial emissions were obtained from the National Pollutant Release Inventory (NPRI). Mean kernel density estimations of the spread of chemicals (Table A4.2) within a 10 km radius of all facilities were averaged within 1km of each DA centroid and assigned to the entire DA by a geographer [41].

2.4   INDICATORS OF VULNERABILITY

2.4.1   Potential indicators of sensitivity

2.4.1.1   Age, sex, and immigrant status

For each DA in Edmonton, 2016 Canadian census data was used to determine average age, the percentage of residents over 65 years, percentage of males (vs females), and the percentages of total, recent (<10 years), long term (≥10 years), economic, and sponsored immigrants and refugees (Table A5) [42]. Unless otherwise specified, refugees are included in immigrant populations.

2.4.1.2   Material and social deprivation

The Material and Social Deprivation Index (MSDI) comprises two systematically identified components, material and social deprivation, built from six socioeconomic indicators from Canadian 2016 census data [43,44]. Material deprivation reflects low income and education and a low employment-to-population ratio. Social deprivation includes being separated, divorced or widowed, and living alone or in a single-parent family. Material and social deprivation factor scores were available for DAs across Edmonton, with lower values indicating most privileged and higher values most deprived or least privileged for both components (Table A5).

2.4.2   Potential indicators of adaptive capacity

2.4.2.1   Greenspace

Greenspace is also shown to be an important predictor of health [45–47]. To explore this variable in Edmonton, we used satellite imagery data to determine the mean value of the Normalized Difference Vegetation Index (NDVI) (-1 to +1) within 1 km of each DA centroid and applied it to the entire DA (Table A5) [48]. Increasing values imply greater amounts of green vegetation. Values below 0.20 correspond to non-vegetation, between 0.20 and 0.50 correspond to low vegetation, and values above 0.50 correspond to high vegetation [49].

2.4.2.2   Active Living Environment

Communities with favorable Active Living Environments (ALE) tend to be densely populated with connected street patterns and various walking destinations conducive to physical activity, which can be protective for health [50,51]. A Canada-wide ALE index from Ross et al., capturing this was available for DAs in Edmonton, with positive values indicating increased favorability relative to the Canadian average (Table A5) [32,50]. Across Canada, ALE index values categorized as those indicating "very low favorability" averaged -1.6, while values that indicated "very high favorability" averaged 9.3 [50].

2.4.2.3   Access to healthcare and social services

This study also investigated whether greater access to healthcare and social services impacted the number of health events in Edmonton (Table A5). This was measured as the number of locations within 1 km of the DA centroid along with the road network for healthcare facilities [52], clinics [53], and active non-profits [54]. Since only 10% of DAs had emergency medical services (EMS) within 1 km, the range

was expanded to calculate the number within 1, 3, and 5 km of the DA centroid [53]. Higher numbers imply greater access to these services.

2.5 STATISTICAL ANALYSIS

This study used aggregated data to explore the effects of climate and air pollution hazards and sensitivity and adaptive capacity indicators on the per capita rate of cardiovascular, injury, mental, and respiratory health events at the DA level in Edmonton, AB. Older adult and immigrant communities were the focus of this study, so measures of proportions capturing age (>65, >75, >85) and immigrant status (total, economic, sponsored, refugees) at the DA level were evaluated to understand the health burden in DAs of these communities from climate change and air pollution exposures.

2.5.1 Descriptive statistics

Descriptive statistics summarized the distribution of the aggregated health, hazard, and community level vulnerability data in terms of frequency, central tendency, range and variation in both tabular and graphical formats over the four-year study period. A health geographer also mapped the spatial distribution of these variables using ArcGIS® Pro version 2.7 (Esri, Redlands, CA, USA). Univariate associations between the weather, air pollution, sensitivity, adaptive capacity measures and health outcomes were examined (Table A6). Data were examined, and missing data were assessed. Edmonton, AB has a total of 1,193 DAs; however, analyses were limited to 1,126 (94%) DAs due to a lack of people residing in these areas and missing independent variables data. Excluding the health events reported in these areas, 10,457 (10%) of cardiovascular events, 5,552 (15%) of injuries, 9,573 (10%) of mental health events, and 3,480 (10%) of respiratory events were removed from the analysis.

2.5.2 Negative binomial regressions

An exploratory approach was used to investigate the effects of exposure to climate- and air pollution-related hazards at the DA level in Edmonton, AB. Both *a priori* and statistically identified (p<0.05 in Wald tests) indicators of vulnerability and climate/air pollution hazards were included in analyses to determine the best fit models. If variance inflation factors (VIF) were above 10, the most clinically plausible variable was selected, or if of interest, the variables were analyzed separately. Variables were considered confounders if, in Wald tests, they altered the coefficients of significant indicators by ten percent or greater [55]. Prevalence rate ratios (PRRs) (Equation A6) and 95% confidence intervals were

determined using negative-binomial regression (NBR) after significant likelihood ratio tests for the alpha parameter in Poisson models indicated over-dispersion.

2.5.2.1 Main effects community-level vulnerability models

Vulnerability is an intrinsic factor and key dimension of health risk within the context of climate change, according to the IPCC AR5 risk framework [20]. To examine this at the community level in Edmonton, a set of unique main effects models based on age and immigrant subgroups for each health outcome were developed using sensitivity and adaptive capacity indicators. The following combinations were explored: the proportion of older adults and total immigrants; average age, recent immigrants, and long-term immigrants; and average age, economic immigrants, sponsored immigrants, and refugees. Since the behavior of the older adult and immigrant measures differed according to health outcome (i.e., in terms of significance and confounding), the number of community-level vulnerability models varied across outcomes (three for cardiovascular, four for injuries, four for mental health, and two for respiratory events).

2.5.2.2 Fully adjusted health impact models

The effects of exposure to climate and air pollution hazards within the context of community-level vulnerability were explored in fully adjusted cardiovascular, injury, mental, and respiratory health impact models. Final models combined climate- and air pollution-related hazards that were significant in univariate models ($p<0.20$) with the community-level vulnerability main effects models for each health outcome. Relevant combinations of hazards for each fully adjusted health impact model (e.g., $PM_{2.5}$, average air temperature, precipitation) were also informed by *a priori* knowledge. Interactions between statistically significant hazards and community-level measures of age and immigrants were included based on Wald tests ($p<0.05$). The fit of the final models, model assumptions, outliers and influential points were visually assessed using standardized deviance residuals (Appendix 7). Statistical analyses were conducted with Stata version 16.1 (StataCorp LLC, College Station, TX).

2.5.3 Ethics

Ethics approval was obtained from the University of Alberta Health Research Ethics Board, Project Name "Climate Change, Older Adults and Immigrants: Exploring Community Vulnerability and Resilience," (PRO 00094359).

3 RESULTS

3.1 DESCRIPTIVE SUMMARY OF COMMUNITY-LEVEL HEALTH, HAZARDS, AND INDICATORS OF VULNERABILITY

There were a total of 888,809 persons across 1,126 DAs in Edmonton, AB in 2016. While the mean age (SD) of the study population in Edmonton was 38.8 (4.9) years, older adults (>65) accounted for over a tenth of Edmonton's population, with a slightly higher proportion of older females (6%) than older males (5%). Nearly one-third (30%) of the Edmonton population were immigrants, of whom over half were admitted as those that can contribute to Canada's economy (16% economic class). Maps illustrating the spatial distribution of proportions of older adults and immigrants (Figure A5) across Edmonton were generated by a geographer (C.C.N) as part of a larger project developing an Edmonton-based mapping index. Between January 1, 2015, and December 31, 2018, there were a total of 90,817 cardiovascular events, 30,529 injuries, 84,385 mental health events, and 34,351 respiratory health events that occurred across 1,126 dissemination areas in Edmonton, Alberta (Table 3.1).

The average temperature in Edmonton across DAs in 2015 was 4.80 (0.09)^{o}C and the mean diurnal temperature change in Edmonton was 12.02 (0.06)^{o}C. Over the study period, the mean concentrations of $PM_{2.5}$, NO_2, O_3 and industrial emissions across DAs in Edmonton were 8.39 (0.77) μg/m^3, 15.17 (2.91) ppb, 31.64 (0.98) ppb, and 4.02 (4.44) tonnes/km^2, respectively. A summary of community-level measures of climate change/air pollution-related health events, hazards, and indicators of sensitivity and adaptive capacity are presented in Table 3.1.

Table 3.1 Descriptive summary of community-level health, hazards, and indicators of vulnerability in Edmonton, 2015-18

DA Characteristic (N= 1,126)	N (%)	Mean (SD)	Min	Max
Health events	*total*	*per 100 DA residents*		
Cardiovascular	90,817	12.1 (10.0)	0	100.0
Injury	30,529	3.9 (3.0)	0	62.4
Mental Health	88,037	11.5 (8.9)	0	88.0
Respiratory	34,351	4.1 (2.4)	0	25.7
Source: Canadian Institute for Health Information Discharge Abstract Database and National Ambulatory Care Reporting System; individual health events aggregated to dissemination areas using postal codes.				
Population demographics				

Population	887,580	787 (919)	90	12,242
Age (years), mean		38.8 (4.92)	22.70	64
Age (years), n (%)				
<65	789,835 (89)	700 (883)	80	11,870
≥65	98,545 (11)	87 (69)	5	650
Sex, n (%)				
Males	444,940 (50)	394 (460)	50	6,125
Females	443,810 (50)	393 (460)	35	6,115
Immigrants, n (%)	265,495 (30)	235 (386)	0	4,545
Long-term immigrants (>10 years)	150,675 (17)	133 (187)	0	2,170
Recent immigrants (<10 years)	115,010 (13)	102 (221)	0	3,255
Admission category				
Refugees	39,035 (5)	35 (52)	0	515
Sponsored	64,175 (9)	57 (114)	0	1,365
Economic	118,310 (16)	105 (229)	0	2,955

Source: Statistics Canada, 2016 Canadian Census [42]; due to the random rounding used for confidentiality in Statistics Canada Census data, percentages and raw numbers may not align.

Material and Social Deprivation				
Material Deprivation	-	-0.011 (0.041)	-0.169	0.130
Social Deprivation	-	0.010 (0.042)	-0.126	0.152

Source: Institut national de santé publique du Québec; Pampalon et al [43,44]; mean values for material and social deprivation in Canada (2016) were 0.004 (SD 0.043) and 0.000 (0.041).

Urban Environment				
NDVI	-	0.193 (0.027)	0.087	0.361
Active Living Environment	-	0.272 (1.072)	-2.103	5.497

Sources: U.S. Geological Survey, Canadian Urban Environment research consortium, Ross et al. [32,48,50].

Access to Healthcare and Social Services				
Social services within 1 km of DA centroid, n	5,708	32 (73)	0	820
Healthcare facilities within 1 km of DA centroid, n	70	0.27 (0.75)	0	6
Clinics within 1 km of DA centroid, n	758	5 (14)	0	113
Emergency Medical Services	19			
Within 1 km of DA centroid, n		0.10 (0.29)	0	1
Within 3 km of DA centroid, n		0.90 (0.72)	0	3
Within 5km of DA centroid, n		2.21 (1.30)	0	6

Sources: Service Alberta, Alberta Health Services, DMTI Spatial [52–54].

Climate and air pollution hazards				
Average Temp. (°C) (2015)*	-	4.80 (0.09)	4.50	5.04
Minimum Temp. (°C) (2015)*	-	-1.21 (0.11)	-1.56	-0.98
Maximum Temp. (°C) (2015)*	-	10.81 (0.09)	10.55	11.07
Diurnal Temp. Range (°C) (2015)*	-	12.02 (0.06)	11.86	12.14
Heat events (count) (2015)*, n	-	11.04 (0.66)	10.00	12.00
Heat warning threshold (days) (2015-18), n	-	17.23 (3.85)	5.45	24.71
Days > MMT (2015-18), n	-	451.25 (8.71)	421.16	461.97
Days < MMT (2015-18), n	-	1006.18 (8.58)	996.03	1033.88

Annual total precipitation as rain (mm) (2015)*	-	187.63 (2.88)	181.17	193.66
Annual total precipitation as snow (mm) (2015)*	-	90.98 (1.30)	85.93	96.21
$PM_{2.5}$ ($\mu g/m^3$) (2015-18)**	-	8.39 (0.77)	6.11	9.45
NO_2 (ppb) (2015-16)**	-	15.17 (2.91)	9.63	27.29
O_3 (ppb) (2015)**	-	31.64 (0.98)	30.66	35.35
NPRI (tonnes/km^2) (2015-18)	-	4.02 (4.44)	0.02	19.82

*Sources: Canadian Urban Environment Consortium, Alberta Climate Information Service [33], National Pollutant Release Inventory [41]; *ANUSPLIN climate models [31,32], **Land Use Regression models [32,36–40]; Heat warning threshold – maximum temperature is >29°C and the minimum temperature is >14°C; MMT – Minimum Mortality Temperature for Edmonton (12.8^{o}C) [35].*

3.2 CARDIOVASCULAR HEALTH EVENTS

3.2.1 Community-level indicators of vulnerability

Table 3.2 presents the results of three distinct main effects models using different measures of age and categorizations of immigrants. Measures consistently indicate increasing age was a risk factor. There was a 5% increase in the per capita rate of cardiovascular health events across DAs with a one percent increase in the proportion of older adults. Conversely, the proportion of both total and economic immigrants demonstrated protective effects for cardiovascular events, with a 5% increase in either corresponding to PRRs of 0.981 (95%CI: 0.0963, 0.999) and 0.953 (95%CI: 0.928, 0.978), respectively. While higher levels of social deprivation were associated with increased risk, increased greenness demonstrated strong protective effects, with an increase of 0.031 (IQR) in the NDVI associated with up to a 12% (95%CI: 7%, 16%) reduction in the rate of cardiovascular events.

Table 3.2 Three main effects models exploring associations between indicators of community-level vulnerability and cardiovascular health events in Edmonton, AB (2015-18)

Sensitivity and Adaptive Capacity Indicators	(1) PRR (95% CI)	(2) PRR (95% CI)	(3) PRR (95% CI)
Age Variables			
Average Age	1.081*** (1.072, 1.091)		1.078*** (1.069, 1.088)
Over 65 (%)		1.051*** (1.044, 1.058)	
Immigrant Status Variables			
Total Immigrants (%)	0.996* (0.992, 1.000)	0.993*** (0.989, 0.996)	
Economic Immigrants (%)			0.990*** (0.985, 0.996)
Social Deprivation Score	1.126***	1.139***	1.131***

(IQR = 0.056)	(1.063, 1.192)	(1.074, 1.207)	(1.070, 1.195)
Greenness (NDVI)	0.873***	0.864***	0.881***
(IQR = 0.031)	(0.829, 0.920)	(0.819, 0.911)	(0.837, 0.927)
Seasonality (% in warmer months)	1.001	1.001	1.001
	(0.998, 1.004)	(0.997, 1.004)	(0.998, 1.004)
Healthcare Facilities within 1km	0.969	0.950	0.971
	(0.905, 1.037)	(0.886, 1.019)	(0.907, 1.038)
Clinics within 1km	0.997	0.998	0.997
	(0.993, 1.000)	(0.995, 1.002)	(0.994, 1.001)
Constant	0.013***	0.175***	0.014***
	(0.008, 0.022)	(0.115, 0.267)	(0.008, 0.023)

*** p<0.001, ** p<0.01, *p<0.05; Negative binomial regressions include the main effects of significant indicators of sensitivity and adaptive capacity and confounding variables reported as prevalence rate ratios (PRR); various measures of age and immigrant status were explored separately using (1) average age and percentage of total immigrants, (2) percentage of older adults (≥65 years) and percentage of total immigrants, and (3) average age and the percentage of economic immigrants.

3.2.2   Impacts of exposure to climate and air pollution related hazards

The effects of the hazards and significant interaction terms (IQR increase) on the rate of cardiovascular events across DAs in fully adjusted models are shown in Table 3.3. An increase in heat events (IQR 0.771) was associated with a PRR of 0.927 (95%CI: 0.884, 0.973) in fully adjusted models accounting for the percentage of older adults in a DA. Increasing diurnal temperature change consistently demonstrated protective effects across models, with a PRR of 0.911 (95%CI: 0.848, 0.980) for an interquartile increase in models adjusting for the percentage of older adults in a DA. Precipitation as rain had a protective effect across all models, with a 5.202 mm (IQR) increase reducing the rate of cardiovascular events by up to 9% (95%CI: 1%, 16%) in fully adjusted models.

At the mean percentage of older adults (12.89%) and total immigrants (26.91%), a 0.845 $\mu g/m^3$ (IQR) increase in $PM_{2.5}$ exposure was associated with a PRR of 1.073 (95%CI: 1.016, 1.133). However, at higher percentages of older adults, this effect was often attenuated and non-significant. A similar effect was observed for low percentages of total immigrants (Table 3.12). Increasing levels of industrial emissions (NPRI) were statistically significant in models accounting for the percentage of older adults (increase of 5 tonnes/km^2 in industrial emissions: PRR=1.08 (95%CI: 1.01, 1.15)). Results also indicated that O_3 was associated with a greater positive effect on the rate of cardiovascular events at higher percentages of older adults (Figure A8.1).

Table 3.3 Adjusted effects of climate related hazards on the rate of cardiovascular health events in Edmonton, AB, including interactions for three different community vulnerability models (2015-18)

Community-Vulnerability Models

Hazard Models	(1) PRR (95%CI)	(2) PRR (95%CI)	(3) PRR (95%CI)
Heat events (2015, ANUSPLIN)	0.927**	0.922**	0.934**
(IQR = 0.711 Events)	(0.884, 0.973)	(0.877, 0.969)	(0.889, 0.980)
Constant	0.367	2.666	0.204
	(0.022, 6.163)	(0.153, 46.328)	(0.010, 4.084)
Heath threshold (2015-18)	0.961	1.006	0.965
(IQR = 5.352 Days)	(0.903, 1.023)	(0.945, 1.072)	(0.907, 1.027)
Constant	0.975	11.524	0.393
	(0.061, 15.480)	(0.717, 185.245)	(0.020, 7.755)
Days > MMT (2015-18)	0.975	1.008	0.978
(IQR = 8.800 Days)	(0.931, 1.021)	(0.963, 1.056)	(0.934, 1.024)
Constant	2.649	8.891	0.933
	(0.147, 47.834)	(0.470, 168.307)	(0.041, 21.267)
Days < MMT (2015-18)	1.025	0.991	1.021
(IQR = 8.854 Days)	(0.978, 1.074)	(0.945, 1.040)	(0.974, 1.070)
Constant	0.002	1.988	0.001
	(0.000, 8.143)	(0.000, 7,974.485)	(0.000, 5.404)
Min. Temp. (2015, ANUSPLIN)	0.999	1.007	1.002
(IQR = 0.118^oC)	(0.953, 1.047)	(0.960, 1.056)	(0.955, 1.050)
Constant	0.064	0.553	0.023
	(0.000, 11.468)	(0.003, 110.790)	(0.000, 4.802)
Diurnal Temp. Range (2015, ANUSPLIN)	0.915*	0.911*	0.921*
(IQR = 0.109^oC)	(0.854, 0.982)	(0.848, 0.980)	(0.858, 0.988)
Constant	7,165.874	122,986.051*	1,434.320
	(0.191, 2.692e+08)	(2.436, 6.210e+09)	(0.031, 6.709e+7)
Average Temp. (2015, ANUSPLIN)	0.949*	0.963	0.953
(IQR = 0.098^oC)	(0.902, 0.998)	(0.914, 1.015)	(0.905, 1.003)
$PM_{2.5}$ (2015-18, LUR)	1.114***	1.089	1.111***
(IQR = 0.845 $\mu g/m^3$)	(1.060, 1.170)	(0.919, 1.290)	(1.057, 1.168)
$PM_{2.5}$ x Older Adults (%)		0.993	
		(0.986, 1.000)	
$PM_{2.5}$ x Immigrants (%)		1.003	
		(0.999, 1.007)	
Constant	0.122	0.762	0.043
	(0.000, 98.938)	(0.001, 831.930)	(0.000, 44.772)
Average Temp. (2015, ANUSPLIN)	0.986	1.004	0.992
(IQR = 0.098^oC)	(0.935, 1.039)	(0.952, 1.060)	(0.940, 1.046)
Industrial emissions (2015-18, NPRI)	1.036	1.062*	1.039
(IQR = 3.800 $tonnes/km^2$)	(0.987, 1.089)	(1.009, 1.117)	(0.990, 1.091)
Constant	0.012	0.003	0.002
	(0.000, 78.389)	(0.000, 24.573)	(0.000, 17.298)
O_3 (2015, LUR)	0.513**	0.733***	0.541*
(IQR = 1.730 ppb)	(0.316, 0.835)	(0.634, 0.848)	(0.332, 0.882)
O_3 x Average Age (years)	1.014*		1.013*
	(1.001, 1.027)		(1.000, 1.026)

O$_3$ x Older Adults (%)		1.013*		
		(1.003, 1.024)		
Constant	2,531.377	48.260**	989.464	
	(0.337, 1.900e+7)	(3.268, 712.637)	(0.129, 7.611e+6)	

*** *p<0.001, ** p<0.01, *p<0.05; MMT – Minimum mortality threshold (12.8ᵒC) [35]; All hazard models adjusted for social deprivation, greenness, seasonality, and the number of healthcare facilities and clinics within 1km; LURs for NO₂ and O₃ accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm); Each model separately adjusted for varying measures of age and immigrant status as follows: (1) average age and the percentage of total immigrants, (2) percentage of older adults and total immigrants, (3) average age and the percentage of economic immigrants.*

3.3 INJURY HEALTH EVENTS

3.3.1   Community-level indicators of vulnerability

Increasing average age and higher percentages of older adults were associated with increased per capita rates of injuries at the level of the DA across models (Table 3.4). Generally, higher proportions of immigrants were protective, with the exception of refugees. A five percent increase in the proportion of refugees was associated with a 4% (95%CI: 1%, 7%) increase in the per capita rate of injuries. Higher levels of material and social deprivation were both risk factors, while a more favorable Active Living Environment was protective. Greater access to healthcare and social services was also typically a risk factor.

Table 3.4 Four main effects models exploring associations between indicators of community-level vulnerability and injuries in Edmonton, AB (2015-18)

Sensitivity and Adaptive Capacity Indicators	(1) PRR (95% CI)	(2) PRR (95% CI)	(3) PRR (95% CI)	(4) PRR (95% CI)
Age Variables				
Average Age (years)	1.059***		1.063***	1.058***
	(1.054, 1.065)		(1.057, 1.068)	(1.052, 1.064)
Over 65 (%)		1.041***		
		(1.037, 1.045)		
Males (%)	1.017***	1.034***	1.017***	1.016***
	(1.008, 1.027)	(1.024, 1.044)	(1.008, 1.027)	(1.007, 1.026)
Immigrant Status Variables				
Total Immigrants (%)	0.996**	0.995***		
	(0.994, 0.999)	(0.992, 0.997)		
Long-term Immigrants (%)			0.994**	
			(0.991, 0.998)	
Refugees (%)				1.007*
				(1.001, 1.013)
Economic Immigrants (%)				0.993***

			(0.989, 0.996)
Material Deprivation Score	1.287***	1.254***	1.277***	1.230***
(IQR = 0.056)	(1.242, 1.335)	(1.209, 1.300)	(1.233, 1.323)	(1.183, 1.279)
Social Deprivation Score	1.225***	1.228***	1.207***	1.227***
(IQR = 0.056)	(1.179, 1.272)	(1.182, 1.276)	(1.158, 1.258)	(1.183, 1.273)
Active Living Environment Index	0.956**	0.957**	0.955**	0.956**
(IQR = 1.329)	(0.927, 0.987)	(0.927, 0.988)	(0.926, 0.985)	(0.927, 0.986)
Social Services within 1km	1.000	1.000	1.000	1.000
	(1.000, 1.001)	(1.000, 1.001)	(1.000, 1.001)	(1.000, 1.001)
Healthcare Facilities within 1km	1.086***	1.074**	1.084***	1.090***
	(1.041, 1.134)	(1.028, 1.121)	(1.038, 1.131)	(1.044, 1.137)
Clinics within 1km	1.005***	1.005***	1.005***	1.005***
	(1.003, 1.008)	(1.003, 1.008)	(1.003, 1.008)	(1.002, 1.007)
EMS within 3km	1.067***	1.072***	1.067***	1.060**
	(1.028, 1.107)	(1.032, 1.114)	(1.028, 1.108)	(1.021, 1.100)
Seasonality (% events in April-September)	1.002	1.002	1.002	1.001
	(1.000, 1.004)	(1.000, 1.004)	(1.000, 1.003)	(1.000, 1.003)
Constant	0.002***	0.004***	0.001***	0.002***
	(0.001, 0.003)	(0.002, 0.007)	(0.001, 0.002)	(0.001, 0.003)

*** p<0.001, ** p<0.01, *p<0.05; Negative binomial regressions include the main effects of significant indicators of sensitivity and adaptive capacity and confounding variables reported as prevalence rate ratios (PRR); various measures of age and immigrant status were explored separately using (1) average age and percentage of total immigrants, (2) percentage of older adults (≥65 years) and percentage of total immigrants, (3) average age and percentage of long-term immigrants (≥10 years in Canada), and (4) average age and the percentage of economic immigrants and refugees.

3.3.2   Impacts of exposure to climate and air pollution related hazards

Results indicated the effects of heat and cold exposure were modified by measures of age (Table 3.5). While the risk of heat events on the rate of injuries was not significant for areas with lower percentages of older adults, the effect was amplified at increasing percentages (PRR=1.053 (95%CI: 1.004, 1.104) at 13% older adults *vs*. PRR=1.160 (95%CI: 1.062, 1.267) at 25% older adults). Generally, increasing temperature was associated with increased risk for higher rates of injuries across community-level vulnerability models. Results suggested there was a threshold effect for maximum temperature on injuries, since the risk diminished and was not significant at higher percentages of economic immigrants (Figure A8.2). The protective effects of rain decreased with increasing age.

Adverse injury effects of increased exposure to industrial emissions increased with higher proportions of refugees. Similar to cardiovascular health models, the effects of O_3 exposure were modified by measures of age. At lower fractions of older adults, an increase in O_3 by 1.73 ppb (IQR) exhibited statistically significant protective effects for injuries (PRR 0.865, 95%CI: 0.809, 0.925 at 5% ≥65

years), but at higher fractions of older adults, this was associated with increased risk (PRR 1.110, 95%CI: 1.011, 1.219 at 25% ≥65 years). Generally, exposure to increasing concentrations of NO_2 was significantly associated with higher rates of injuries across DAs in Edmonton.

Table 3.5. Adjusted effects of climate-related hazards on the rate of injury events in Edmonton, AB, including interactions for four different community vulnerability models (2015-18)

	Community Vulnerability Models			
	(1)	(2)	(3)	(4)
Hazard Models	**PRR (95%CI)**	**PRR (95%CI)**	**PRR (95%CI)**	**PRR (95%CI)**
Heat events (2015)	0.754*	0.963	0.730*	0.837
(IQR = 0.711 Events)	(0.593, 0.959)	(0.897, 1.033)	(0.573, 0.930)	(0.664, 1.054)
Heat events x Average Age (years)	1.009**		1.008*	1.007*
	(1.002, 1.015)		(1.002, 1.014)	(1.001, 1.012)
Heat events x Older Adults (%)		1.006*		
		(1.001, 1.010)		
Heat events x Long-term Immigrants (%)			1.003	
			(0.999, 1.006)	
Heat events x Economic Immigrants (%)				0.998
				(0.994, 1.002)
Constant	36.012	1.427	67.654	0.628
	(0.000, 1.256e+7)	(0.036, 56.221)	(0.000, 2.403e+7)	(0.012, 32.254)
Heat threshold (2015-18)	0.785	1.127***	0.756	0.814
(IQR = 5.352 Days)	(0.590, 1.047)	(1.079, 1.177)	(0.567, 1.009)	(0.611, 1.083)
Heat threshold x Average Age (years)	1.009*		1.007	1.008*
	(1.002, 1.017)		(1.000, 1.015)	(1.001, 1.016)
Heat threshold x Long-term Immigrants (%)			1.006*	
			(1.001, 1.011)	
Constant	3.769e+4	16.071	1.500e+5*	0.069*
	(0.360, 3.944e+9)	(0.560, 4.609e+2)	(1.387, 1.621e+10)	(0.007, 0.687)
Days > MMT (2015-18)	0.831	1.091***	0.808	0.831
(IQR = 8.800 Days)	(0.670, 1.030)	(1.056, 1.127)	(0.651, 1.003)	(0.674, 1.024)
Days > MMT x Average Age	1.007*		1.006*	1.007*
	(1.001, 1.013)		(1.001, 1.012)	(1.001, 1.012)
Days > MMT x Long-term Immigrants			1.003	
			(1.000, 1.007)	
Constant	2.504e+8**	1.030	2.100e+9**	934.442
	(2.323e+2, 2.698e+14)	(0.036, 29.872)	(1.699e+3, 2.595e+15)	(0.023, 3.769e+8)
Days < MMT (2015-18)	1.207	0.914***	1.240	1.207
(IQR = 8.854 Days)	(0.970, 1.503)	(0.884, 0.945)	(0.994, 1.546)	(0.977, 1.493)
Days < MMT x Average Age	0.993*		0.994*	
	(0.987, 0.999)		(0.988, 0.999)	
Days < MMT x Long-term Immigrants			0.997	
			(0.994, 1.000)	
Constant	0.000	4.416e+6***	0.000	0.000

	(0.000, 2.111e+08)	(8.967e+3, 2.175e+09)	(0.000, 1.613e+7)	(0.000, 3.292)
Min. Temp. (^{o}C, 2015, ANUSPLIN)	1.021	1.025	1.021	1.016
(IQR = 0.118^{o}C)	(0.989, 1.053)	(0.993, 1.058)	(0.989, 1.053)	(0.984, 1.049)
Constant	0.073	0.149	0.076	0.017*
	(0.003, 1.985)	(0.005, 4.241)	(0.003, 2.007)	(0.001, 0.534)
Max. Temp. (^{o}C, 2015, ANUSPLIN)	1.080**	1.076**	1.075**	1.154***
(IQR = 0.112^{o}C)	(1.030, 1.132)	(1.026, 1.129)	(1.026, 1.127)	(1.073, 1.241)
Max. Temp. x Economic Immigrants (%)				0.995*
				(0.990, 0.999)
Constant	0.000***	0.000**	0.000***	0.000***
	(0.000, 0.003)	(0.000, 0.012)	(0.000, 0.006)	(0.000, 0.000)
Average Temp. (^{o}C, 2015, ANUSPLIN)	1.030	1.034	1.030	1.028
(IQR = 0.098^{o}C)	(0.995, 1.067)	(0.998, 1.071)	(0.995, 1.066)	(0.992, 1.064)
PM$_{2.5}$ (2015-18, LUR)	1.026	1.018	1.023	1.028
(IQR = 0.845 µg/m^3)	(0.991, 1.062)	(0.983, 1.055)	(0.987, 1.060)	(0.993, 1.063)
Constant	0.003**	0.005*	0.003*	0.001**
	(0.000, 0.235)	(0.000, 0.507)	(0.000, 0.272)	(0.000, 0.066)
Average Temp. (2015, ANUSPLIN)	1.054**	1.059**	1.055**	1.053**
(IQR = 0.098^{o}C)	(1.018, 1.091)	(1.022, 1.097)	(1.019, 1.093)	(1.017, 1.091)
Industrial emissions (2015-18, NPRI)	1.009	1.066***	1.059***	1.061***
(IQR = 3.800 tonnes/km^2)	(0.961, 1.060)	(1.031, 1.101)	(1.026, 1.094)	(1.028, 1.095)
Industrial emissions x Immigrants (%)	1.002*			
	(1.000, 1.005)			
Industrial emissions x Refugees (%)				1.494*
				(1.043, 2.140)
Constant	0.000***	0.000***	74.603	0.000***
	(0.000, 0.001)	(0.000, 0.002)	(0.000, 1.668e+7)	(0.000, 0.000)
O$_3$ (2015, LUR)	0.965	0.813***	0.957	0.987
(IQR = 1.730 ppb)	(0.917, 1.015)	(0.744, 0.889)	(0.910, 1.006)	(0.937, 1.040)
O$_3$ x Older Adults (%)		1.013***		
		(1.006, 1.019)		
Constant	0.003***	0.182	0.003***	0.002***
	(0.001, 0.009)	(0.032, 1.021)	(0.001, 0.010)	(0.001, 0.006)
NO$_2$ (2015-16, LUR)	1.038	1.050*	1.039	1.045*
(IQR = 3.901 ppb)	(0.999, 1.079)	(1.009, 1.092)	(1.000, 1.080)	(1.006, 1.085)
Constant	0.001***	0.003***	0.001***	0.001***
	(0.001, 0.002)	(0.002, 0.006)	(0.001, 0.002)	(0.001, 0.003)

*** p<0.001, ** p<0.01, *p<0.05; MMT – Minimum mortality threshold (12.8^{o}C) [35]; Models adjusted for material and social deprivation, Active Living Environment, seasonality, and the number of healthcare facilities, clinics, and social services within 1km, and the number of EMS within 3km; LURs for NO$_2$ and O$_3$ accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm); Each community-vulnerability model separately adjusted for varying measures of age and immigrant status as follows: (1) average age and percentage of total immigrants, (2) percentage of older adults (≥65 years) and percentage of total immigrants, (3) average age and percentage of long-term immigrants (≥10 years in Canada), and (4) average age and the percentage of economic immigrants and refugees.

3.4 MENTAL HEALTH EVENTS

3.4.1 Community level indicators of vulnerability

A number of community-level factors impacted the per capita rates of mental health events at the DA level in Edmonton (Table 3.6). Risk factors included increasing age and higher levels of material and social deprivation. An interquartile range increase (0.056) resulted in material and social deprivation PRRs of 1.302 (95%CI: 1.230, 1.378) and 1.239 (95% CI: 1.166, 1.315), respectively. A decrease in the rate of mental health events was observed with higher percentages of immigrants across DAs. A five percent increase in the proportion of economic immigrants was associated with a 7% (95% CI: 5%, 10%) decrease in the rate of mental health events across DAs.

Table 3.6 Four main effects models exploring associations between indicators of community-level vulnerability and mental health events in Edmonton, AB (2015-18)

Sensitivity and Adaptive Capacity Indicators	(1) PRR (95% CI)	(2) PRR (95% CI)	(3) PRR (95% CI)	(4) PRR (95% CI)
Age Variable				
Average Age	1.041*** (1.033, 1.050)		1.037*** (1.028, 1.046)	1.038*** (1.029, 1.046)
Over 65 years (%)		1.027*** (1.021, 1.033)		
Immigrant Status Variables				
Total Immigrants (%)	0.991*** (0.987, 0.995)	0.990*** (0.986, 0.993)		
Recent Immigrants (%)			0.988*** (0.983, 0.993)	
Economic Immigrants (%)				0.984*** (0.979, 0.989)
Material Deprivation Score (IQR = 0.056)	1.302*** (1.230, 1.378)	1.274*** (1.203, 1.348)	1.309*** (1.239, 1.384)	1.250*** (1.185, 1.318)
Social Deprivation Score (IQR = 0.056)	1.239*** (1.166, 1.315)	1.233*** (1.161, 1.310)	1.303*** (1.228, 1.382)	1.268*** (1.197, 1.345)
Greenness (NDVI) (IQR = 0.031)	0.979 (0.926, 1.035)	0.975 (0.922, 1.030)		
Clinics within 1km	1.001 (0.999, 1.004)	1.002 (0.999, 1.005)	1.001 (0.999, 1.004)	1.002 (0.999, 1.004)
EMS within 5km	1.038* (1.002, 1.075)	1.049** (1.013, 1.086)	1.042* (1.007, 1.078)	1.030 (0.996, 1.067)
Seasonality (% events in April-September)	1.007*** (1.004, 1.009)	1.006*** (1.004, 1.009)	1.007*** (1.004, 1.009)	1.007*** (1.004, 1.009)
Constant	0.022***	0.077***	0.019***	0.020***

| | (0.013, 0.038) | (0.051, 0.118) | (0.013, 0.029) | (0.014, 0.029) |

*** p<0.001, ** p<0.01, *p<0.05; Negative binomial regressions include the main effects of significant indicators of sensitivity and adaptive capacity and confounding variables reported as prevalence rate ratios (PRR); various measures of age and immigrant status were explored separately using (1) average age and percentage of total immigrants, (2) percentage of older adults (≥65 years) and percentage of total immigrants, (3) average age and percentage of recent immigrants (<10 years in Canada), and (4) average age and the percentage of economic immigrants.*

3.4.2   Impacts of exposure to climate and air pollution related hazards

Overall, very few of the climate and air pollution hazards we explored were significant predictors of mental health events across DAs in fully adjusted models (Table 3.7). Measures of heat exposure and increased temperature had positive associations with mental health, but results were not consistent. Rain was the only climate-related variable that was consistently significant across community-level vulnerability models, with a 5.202 mm (IQR) increase in rain associated with approximately a 21% decrease in the rate of mental health events.

Increasing industrial emissions was only a significant risk factor at higher percentages of immigrants. When the fraction of total immigrants was 5%, a 3.8 tonne/km^2 (IQR) increase in industrial emissions was associated with a PRR of 0.972 (95%CI: 0.909, 1.039) compared to a PRR of 1.081 (95%CI: 1.022, 1.144) when the fraction of total immigrants increased to 25% in models adjusted for the proportion of older adults. The protective effect of a higher proportion of immigrants diminished at higher levels of industrial emissions (Figure A8.3). Similar to other outcomes, increasing concentrations of O_3 demonstrated protective effects in main effects models.

Table 3.7 Adjusted effects of climate-related hazards on the rate of mental health events in Edmonton, AB, including interactions for four different community vulnerability models (2015-18)

| | Community Vulnerability Models | | | |
| | (1) | (2) | (3) | (4) |
Hazard Models	PRR (95%CI)	PRR (95%CI)	PRR (95%CI)	PRR (95%CI)
Heat events (2015)	1.017	1.016	1.023	1.030
(IQR = 0.711 Events)	(0.968, 1.069)	(0.967, 1.068)	(0.974, 1.076)	(0.980, 1.083)
Constant	26.931*	76.715**	29.039*	8.391
	(1.418, 5.116e+2)	(4.178, 1.409e+3)	(1.523, 5.538e+4)	(0.390, 180.583)
Heath threshold (2015-18)	0.980	1.000	0.993	0.991
(IQR = 5.352 Days)	(0.912, 1.054)	(0.930, 1.075)	(0.923, 1.068)	(0.921, 1.065)
Constant	15.093	62.319**	19.606	5.314
	(0.644, 3.535e+2)	(2.804, 1.385e+3)	(0.849, 452.959)	(0.201, 1.408e+2)
Min. Temp. (2015, ANUSPLIN)	1.000	1.006	0.999	1.000
(IQR = 0.118°C)	(0.953, 1.049)	(0.958, 1.055)	(0.953, 1.048)	(0.954, 1.049)

Constant	8.530e+3**	3.459e+3**	1.336e+3**	2.220e+2*
	(5.368, 1.355e+6)	(22.101, 5.415e+5)	(8.973, 1.900e+6)	(1.230, 4.08e+4)
Max. Temp. (2015, ANUSPLIN)	0.873	0.854*	1.007	1.016
(IQR = 0.112°C)	(0.750, 1.017)	(0.733, 0.994)	(0.939, 1.080)	(0.947, 1.089)
Max. Temp. x Immigrants	1.005*	1.006*		
	(1.000, 1.009)	(1.001, 1.010)		
Constant	1.361e+9*	5.694e+10**	5.028e+2	24.664
	(18.208, 1.017e+17)	(766.612, 4.230e+18)	(0.008, 3.142e+7)	(0.000, 1.986e+6)
Diurnal Temp. Range (2015, ANUSPLIN)	1.009	0.999	1.012	1.018
(IQR = 0.109°C)	(0.940, 1.083)	(0.930, 1.072)	(0.943, 1.086)	(0.948, 1.093)
Constant	262.037	4.35E+03	2.677e+2	19.761
	(0.005, 1.310e+7)	(0.088, 2.138e+8)	(0.006, 1.211e+8)	(0.000, 1.116e+7)
Average Temp. (2015, ANUSPLIN)	0.997	0.898	0.995	1.000
(IQR = 0.098°C)	(0.946, 1.051)	(0.795, 1.014)	(0.945, 1.048)	(0.950, 1.053)
Average Temp. x Immigrants (%)		1.004*		
		(1.000, 1.007)		
$PM_{2.5}$ (2015-18, LUR)	1.018	1.006	1.029	1.021
(IQR = 0.845 $\mu g/m^3$)	(0.965, 1.074)	(0.953, 1.062)	(0.977, 1.084)	(0.968, 1.076)
Constant	6.337e+2	1.257e+7**	7.556e+2	1.169e+2
	(0.829, 4.846e+5)	(1.412e+2, 1.122e+10)	(0.999, 5.714e+5)	(0.128, 1.064e+5)
Average Temp. (2015, ANUSPLIN)	1.011	1.020	1.008	1.013
(IQR = 0.098°C)	(0.959, 1.065)	(0.968, 1.075)	(0.957, 1.061)	(0.962, 1.067)
Industrial emissions (NPRI)	0.931	0.946	1.001	1.035
(IQR = 3.800 $tonnes/km^2$)	(0.861, 1.007)	(0.875, 1.024)	(0.947, 1.058)	(0.986, 1.087)
Industrial Emissions x Immigrants (%)	1.005**	1.005**		
	(1.002, 1.009)	(1.002, 1.009)		
Industrial Emissions x Recent Immigrants (%)			1.005*	
			(1.001, 1.009)	
Constant	6.603	3.769	13.812	3.470
	(0.001, 3.689e+4)	(0.001, 2.168e+4)	(0.003, 7.111e+4)	(0.001, 1.992e+4)
O^3 (2015, LUR)	0.918*	0.903*	0.916*	0.942
(IQR = 1.730 ppb)	(0.847, 0.995)	(0.833, 0.979)	(0.845, 0.993)	(0.868, 1.023)
Constant	0.109**	0.508	0.101**	0.061***
	(0.022, 0.546)	(0.108, 2.381)	(0.021, 0.479)	(0.013, 0.295)
NO^2 (2015-16, LUR)	1.003	1.016	1.023	1.020
(IQR = 3.901 ppb)	(0.943, 1.068)	(0.955, 1.081)	(0.964, 1.087)	(0.962, 1.083)
Constant	0.022***	0.072***	0.018***	0.019***
	(0.012, 0.040)	(0.043, 0.121)	(0.012, 0.028)	(0.013, 0.029)

*** $p<0.001$, ** $p<0.01$, *$p<0.05$; Models adjusted for material and social deprivation, greenness (ndvi), seasonality, and the number of clinics and social services within 1km, and the number of EMS within 5km; LURs for NO_2 and O_3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm); Each community-vulnerability model separately adjusted for varying measures of age and immigrant status as follows: (1) average age and percentage of total immigrants, (2) percentage of older adults (≥65 years) and percentage of total immigrants, (3) average age and percentage of recent immigrants (<10 years in Canada), and (4) average age and the percentage of economic immigrants.

3.5 RESPIRATORY HEALTH EVENTS

3.5.1   Community level indicators of vulnerability

Table 3.8 presents the results of the two distinct main effects models describing community-level vulnerability to respiratory events using two different measures of age (average age, percent >65 years). In both models, higher percentages of refugees were associated with increased rates of respiratory events across DAs. The effect size for respiratory events for both average age (1.034 95%CI: 1.028, 1.040) and the percentage over 65 years (1.022 95%CI: 1.018, 1.027) were smaller compared to other health events. A more favorable Active Living Environment was associated with lower rates of respiratory health events regardless of the measure of age used in assessing community-level vulnerability.

Table 3.8 Two main effects models exploring associations between indicators of community-level vulnerability and respiratory health events in Edmonton, AB (2015-18)

Sensitivity and Adaptive Capacity Indicators	(1) PRR (95% CI)	(2) PRR (95% CI)
Age Variables		
Average Age (years)	1.034***	
	(1.028, 1.040)	
Over 65 (%)		1.022***
		(1.018, 1.027)
Immigrant Status Variables		
Refugees (%)	1.017***	1.015***
	(1.011, 1.024)	(1.008, 1.022)
Material Deprivation Score	1.230***	1.217***
(IQR = 0.056)	(1.175, 1.289)	(1.162, 1.275)
Social Deprivation Score	1.082***	1.095***
(IQR = 0.056)	(1.036, 1.131)	(1.051, 1.141)
Active Living Environment Index	0.931***	0.933***
(IQR = 1.329)	(0.900, 0.964)	(0.902, 0.965)
Greenness (NDVI)	1.026	1.017
(IQR = 0.031)	(0.983, 1.071)	(0.974, 1.061)
Healthcare Facilities within 1km	1.068**	1.061*
	(1.017, 1.121)	(1.010, 1.114)
Seasonality (% in warmer months)	1.002*	1.002*
	(1.000, 1.004)	(1.000, 1.004)
Clinics within 1km	1.002	1.002
	(0.999, 1.005)	(0.999, 1.005)
EMS within 5km	1.005	
	(0.978, 1.032)	
Constant	0.008***	0.024***
	(0.005, 0.012)	(0.018, 0.032)

*** p<0.001, ** p<0.01, *p<0.05; Negative binomial regressions include the main effects of significant indicators of sensitivity and adaptive capacity and confounding variables reported as prevalence rate ratios (PRR); various measures of age and immigrant status were explored separately using (1) the percentage of older adults (≥65 years) and percentage of total immigrants, and (2) average age and the percentage of economic immigrants and refugees.*

3.5.2   Impacts of exposure to climate and air pollution related hazards

Higher minimum temperatures were associated with an increase in respiratory health events (Table 3.9). While the effect of a 0.118°C (IQR) increase was significant when models adjusted for the percent of older adults (PRR 1.038 95%CI: 1.003, 1.075), it was only marginally significant (0.1<p≤0.05) in models adjusting for average age (PRR 1.035 95%CI: 0.999, 1.073). Increased diurnal temperature range demonstrated protective effects with lower percentages of refugees, but these effects diminish and reverse with higher fractions of refugees (Figure A8.4). In general, higher levels of $PM_{2.5}$ and industrial pollution (NPRI) were associated with increased rates of respiratory events in DAs.

Table 3.9 Adjusted effects of climate related hazards on the rate of respiratory health events in Edmonton, AB, including interactions for four different community vulnerability models (2015-18)

| | Community Vulnerability Models | |
| | (1) | (2) |
Hazard Models	PRR (95%CI)	PRR (95%CI)
Heat events (2015)	0.983	0.981
(IQR = 0.711 Events)	(0.947, 1.021)	(0.945, 1.019)
Constant	0.017***	0.073*
	(0.002, 0.165)	(0.009, 0.579)
Min. Temp. (2015, ANUSPLIN)	1.035	1.038*
(IQR = 0.118°C)	(0.999, 1.073)	(1.003, 1.075)
Constant	0.065	0.295
	(0.002, 2.557)	(0.009, 9.858)
Max. Temp. (2015, ANUSPLIN)	1.023	1.026
(IQR = 0.112°C)	(0.971, 1.079)	(0.974, 1.080)
Constant	0.003	0.013
	(0.000, 8.986)	(0.000, 35.832)
Diurnal Temp. Range (2015, ANUSPLIN)	0.887***	0.761***
(IQR = 0.109°C)	(0.828, 0.950)	(0.676, 0.857)
Diurnal Temp. Change x Refugees (%)	1.015**	1.020***
	(1.004, 1.027)	(1.009, 1.032)
Diurnal Temp. Change x Over 65 years (%)		1.011**
		(1.004, 1.018)
Constant	1.014e+5*	6.868e+12***
	(10.937, 9.403e+8)	(8.923e+7, 5.286e+18)
Average Temp. (2015, ANUSPLIN)	1.021	1.022
(IQR = 0.098°C)	(0.982, 1.061)	(0.984, 1.062)
$PM_{2.5}$ (2015-18, LUR)	1.042*	1.038
(IQR = 0.845 µg/m3)	(1.002, 1.083)	(0.998, 1.079)
Constant	0.003*	0.014
	(0.000, 0.391)	(0.000, 1.554)

Average Temp. (2015, ANUSPLIN)	1.045*	1.052**
(IQR = 0.098°C)	(1.005, 1.086)	(1.012, 1.092)
Industrial emissions (NPRI)	1.032	1.067***
(IQR = 3.800 tonnes/km^2)	(0.990, 1.077)	(1.028, 1.107)
Industrial Emissions x Refugees (%)	1.005*	
	(1.000, 1.009)	
Constant	0.000***	0.000***
	(0.000, 0.010)	(0.000, 0.011)
O$_3$ (2015, LUR)	0.955	0.938*
(IQR = 1.730 ppb)	(0.901, 1.011)	(0.889, 0.990)
Constant	0.020***	0.077***
	(0.006, 0.064)	(0.027, 0.216)
NO$_2$ (2015-16, LUR)	0.964	0.986
(IQR = 3.901 ppb)	(0.922, 1.007)	(0.946, 1.028)
Constant	0.009***	0.026***
	(0.006, 0.015)	(0.018, 0.037)

*** p<0.001, ** p<0.01, *p<0.05; Models adjusted for material and social deprivation, greenness (NDVI), Active Living Environment, seasonality, and the number of healthcare facilities and clinics within 1km, and the number of EMS within 5km; LURs for NO$_2$ and O$_3$ accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm); Each community-vulnerability model separately adjusted for varying measures of age and immigrant status as follows: (1) average age and percentage of refugees, (2) percentage of older adults (≥65 years) and percentage of refugees.

3.6 SUMMARY OF SIGNIFICANT INDICATORS OF HEALTH RISK

Indicators of vulnerability and exposure to hazards that were significantly associated (p<0.05) with the per capita rate of cardiovascular, injury, mental, and respiratory health outcomes at the DA level are summarized in Table 3.10.

Table 3.10 Summary of significant associations between cardiovascular, injury, mental, and respiratory health events and indicators of community-level vulnerability and exposure to hazards in Edmonton, AB (2015-18). An increase or decrease in an indicator is denoted by ↑ or ↓, respectively, while a * indicates a significant interaction.

Outcome	Indicators of community vulnerability	Community hazard exposure
Cardiovascular Health Events	Risk factors	
	↑ Average age	↑ PM$_{2.5}$ *with ↓ age*
	↑ Over 65 years (%)	↑ Industrial emissions
	↑ Social Deprivation	↑ O$_3$ *with ↑age*
	Protective factors	
	↑ Total Immigrants (%)	↑ Heat events
	↑ Economic Immigrants (%)	↑ Average Temp.
	↑ Greenness (NDVI)	↑ Diurnal Temp. Range
		↑ Rain
Injuries	Risk factors	
	↑ Average age	↑ Heat events
	↑ Over 65 years (%)	↑ Average Temp.
	↑ Male (%)	↑ Max. Temp.
	↑ Refugee (%)	↑ Days > MMT *with ↑average age*
	↑ Social Deprivation	↑ Industrial emissions *with ↑ immigrants (%)*
	↑ Material Deprivation	↑ O$_3$ *with ↑ over 65 years (%)*

	↑ Healthcare facilities within 1km ↑ Clinics within 1km ↑ Emergency Medical services within 1km	↑ NO_2
	Protective factors	
	↑ Total Immigrants (%) ↑ Economic Immigrants (%) ↑ Active Living Environment	↑ Days < MMT *with ↑ average age* ↑ Rain
Mental Health Events	Risk factors	
	↑ Average age ↑ Over 65 years (%) ↑ Social Deprivation ↑ Material Deprivation ↑ Emergency Medical services within 1km	↑ Industrial emissions *with ↑ immigrants (%)*
	Protective factors	
	↑ Total Immigrants (%) ↑ Economic Immigrants (%)	↑ O_3 ↑ Rain
Respiratory Health Events	Risk factors	
	↑ Average age ↑ Over 65 years (%) ↑ Refugee (%) ↑ Social Deprivation ↑ Material Deprivation ↑ Healthcare facilities within 1km	↑ Min. Temp. ↑ $PM_{2.5}$ ↑ Industrial emissions *with ↑ refugees (%)*
	Protective factors	
	↑ Active Living Environment	↑ Diurnal Temp. Range ↑ O_3 ↑ Rain

MMT – Minimum mortality threshold (12.8^{o}C) [35]

4 DISCUSSION

4.1 SUMMARY OF FINDINGS

This study explored how exposure to climate and air pollution hazards within the context of community-level vulnerability, characterized by indicators of sensitivity and adaptive capacity, impact health at the DA level, with a focus on older adults and immigrants. As expected, measures of increasing age were associated with increased rates of adverse health events. DAs with higher proportions of economic immigrants demonstrated decreased risk, while higher proportions of refugees were associated with increased risk for higher rates of health events. In addition to measures of age and immigrants, material and social deprivation were consistently indicators of sensitivity across health outcomes. Green space and favorable Active Living Environments lowered risks, an indicator of greater adaptive capacity. Exposure to increasing temperatures and measures of heat, and higher levels of $PM_{2.5}$, NO_2, and industrial emissions were primarily risk factors for adverse health outcomes. Higher

exposure to O_3 tended to be protective, likely reflecting the inverse relationship between O_3 and NO_2 [56]. Precipitation was typically protective. However, associations between exposure to climatic and air pollution hazards and adverse health risks at the dissemination area (DA) level were dependent upon the type of health event, and the effects of certain hazards were modified by the proportions of immigrants and older adults in a DA (e.g., O_3 and cardiovascular health).

4.2 COMMUNITY-LEVEL INDICATORS OF VULNERABILITY

4.2.1 Potential indicators of sensitivity

4.2.1.1 Age

Irrespective of the health outcome, higher proportions of older adults were significantly associated with higher rates of health events in Edmonton at the DA level, an indicator of sensitivity. Existing literature suggests this likely reflects factors that limit coping capacity in older persons. Factors could include physiological changes that affect their thermoregulation, cardiovascular and respiratory strength, and mobility challenges [2–9]. Social determinants like a lack of social support and poorer individual access to and utilization of health and welfare services also likely play a role [10,58,59].

4.2.1.2 Immigrant status

Lower proportions of total and economic immigrants and higher proportions of refugees were each identified as significant indicators of increased sensitivity. These results reflect the heterogeneity of immigrants living in Edmonton and are consistent with other studies that observed differences in health status between immigrant subgroups [13,60,61]. However, very little has been assessed within the context of climate change or air pollution in Canada. It will be important to explore the different determinants of health risk and resilience to climate change and air pollution within subgroups of immigrants.

4.2.1.3 Sex

Community-level sex distribution was not a significant indicator of sensitivity for most of the health outcomes, which is consistent with a number of Canadian studies identified in a recent scoping review [18]. The one exception was in injury models, where a higher percentage of males was a risk factor. Similarly, a Montreal study found freezing rain was associated with an increase in fall-related injuries, particularly among older adult males [62]. Several other studies found males were at greater

risk of injury due to heat and air pollution exposure [63,64]. However, there may be additional health outcomes not explored in this study for which sex is a relevant indicator of community-level sensitivity. In addition to physiological sex differences, gender norms and roles can produce gender inequalities that may contribute to poor health under future climate change scenarios [65].

4.2.1.4   Material and Social Deprivation

Both material and social deprivation were consistently associated with increased risk across all the health outcomes studied. Material and social deprivation are key social determinants of health and have been individually linked to adverse climate- and air pollution-related health outcomes in Canada [18]. Likewise, social isolation has been linked to poorer health outcomes related to climate and air pollution, particularly in older adults [66–68]. For example, social isolation may limit the amount of support or assistance older adults experience during extreme heat events [68]. These results illustrate an existing sensitivity in Edmonton that could exacerbate exposure to hazards.

4.2.2   Potential indicators of adaptive capacity

4.2.2.1   Greenspace and Active Living Environments

Greenspace, measured using the normalized difference vegetation index, was strongly protective in cardiovascular health models. Research has indicated increased greenspace may boost community-level adaptive capacity through the mitigation of urban heat islands [45] and air pollution [47], in addition to the promotion of community cohesion and physical activity [46].

A Canada-wide Active Living Environment (ALE) index based on dwelling density, connected street patterns, and various walking destinations [50] was used to measure how conducive DAs were to active living. Results from this study indicated that a more favorable ALE had a significant protective effect for injuries and respiratory health outcomes. This may reflect improved health status in these areas since people living in a more favorable ALE may be more physically active, which can contribute to increased physical fitness (e.g., improved muscle strength and respiratory function) and better overall health, in both the general population and in older adults [69].

4.2.2.2   Access to health and social services

Contrary to expectations, higher numbers of healthcare and social services within a given distance of a DA centroid were frequently risk factors. While these measures may capture geographical proximity

to place of residence, it does not measure where people are seeking care. In the case of emergency services and urgent care, people may go where facility estimated wait-times are shorter, regardless of geographic proximity. Similarly, hospitals tend to have specialized care for certain conditions. Additionally, these services may not be accessible or utilized by all community members. Language barriers, knowledge of available care services, cultural differences, and lack of experience in cultural competencies of service providers, among others have been shown to affect accessibility to and the effectiveness of the healthcare and social services in immigrant communities in Canada [17,70,71]. Overall distrust and fear of healthcare and providers could also impact the utilization of health services [72]. Other measures of community-level access to health and social services should be explored to clarify the role it exerts on community health within the context of preparedness for climate change impacts.

4.3   IMPACT OF CLIMATE CHANGE AND AIR POLLUTION HAZARDS ON COMMUNITY HEALTH

4.3.1   Cardiovascular health events

Communities with higher percentages of older adults were associated with higher rates of cardiovascular health events, regardless of the hazard. In contrast to most epidemiological literature [9,18,73], exposure to heat events and increased average temperature tended to be associated with a decrease in cardiovascular health events in this study. Increased circulatory demand during heat events raises the risk of cardiovascular mortality for people of all ages, but especially for older people, whose physiology, even with healthy ageing, places them at a higher risk [57]. Summer temperatures in Edmonton during the study period may not have been high enough to put cardiovascular health at risk, or unexplored factors could have influenced the results. For example, locations with high rates of cardiovascular events could have also been equipped with effective adaption measures (e.g., use of air conditioners [74]) that minimized the effect of heat on cardiovascular health, which were not captured in the study.

Increasing diurnal temperature range (DTR) was protective in cardiovascular health impact models, which is somewhat inconsistent with existing literature [75]. However, the effects of increasing DTR on mortality have been shown to be lower in cooler countries [76]. In the context of Edmonton's presently cooler climate, an increasing DTR may reflect lower nocturnal temperatures, which have been shown to be protective against adverse cardiovascular health impacts [76,77].

Increasing PM$_{2.5}$ exposure was a significant risk factor for higher rates of cardiovascular health events at the DA level, which is consistent with Canadian literature [18]. The effect of PM$_{2.5}$ was attenuated and not significant at higher proportions of older adults. Results may reflect behavioral factors that decrease exposure in older adults, such as staying inside during poor air quality events or reduced mobility, which was not measured at the DA level. The protective effect of higher O$_3$ exposure on rates of cardiovascular events diminished with increased average age and proportions of older adults. Another Canadian-based study found similar results where older females had higher risks associated with O$_3$ and circulatory mortality compared to younger age groups [78]. Increased ground-level O$_3$ concentrations are projected to be a direct consequence of climate change [79], which is a critical consideration for older adult populations.

Rain tended to have protective effects on cardiovascular health. Increased rain can contribute to reducing exposure to hazards associated with adverse health outcomes through lowering the temperature (via evaporative cooling) and scavenging ambient air pollution from the atmosphere [80].

4.3.2   Injury health events

Of all the health outcomes we explored, increasing temperatures and heat exposure had the greatest effect on the rate of injuries at the DA level. These adverse effects also increased with increasing age. Similarly, the protective effects of cooler days (days < 12.8^{o}C) [35] against higher rates of injury intensified with increasing age. Notably, our findings contrast with a number of studies in older adults that identified decreasing temperature as a risk factor for injuries [81–84]. However, a recent cohort study in the mid-Atlantic United States found increasing average temperature was associated with significantly increased odds of injurious falls in older adults with glaucoma, which were more likely to occur outdoors as temperatures increased [85]. The observed associations between warmer temperatures and increased rates of injuries at the DA level could be because warmer weather may encourage outdoor activities, and older adults in Edmonton may also be less inclined to go outdoors in cooler temperatures when conditions can be icy and challenging for those with decreased mobility. Studies have also shown older employees are more likely to suffer traumatic brain and fall-related injuries than younger workers [86,87], and injuries in older workers (but not younger) have been shown to peak in the summer [87]. It is important to note, that these results do not necessarily signify that the injuries are occurring in older persons. Rather, injuries occurred in areas with higher proportions of older residents. Increasing measures of age at the DA level also reduced the protective effect of rain in

injury models. This may be because wet, slippery conditions produced by rain can create an environment conducive to outdoor injuries in older adults [88].

The protective effect of O_3 exposure on the rate of injuries decreased with higher proportions of older adults. NO_2 was a significant risk factor in injury models adjusting for older adults and all immigrants. Research in both toxicology and epidemiology has linked exposure to air pollution, including O_3 and NO_2, to central nervous system diseases (CNS), cognitive and behavioral deficits, and neurotoxicity [89–91]. Since CNS diseases and cognitive impairment are known risk factors for fall-related injuries in older people [92], this may partly explain the relationships between O_3, NO_2 and injuries observed in this study.

Findings indicated the effects of increasing maximum temperature on injuries decreased with higher proportions of economic immigrants, which is loosely reflected in results from a cross-sectional survey study in Canada where immigrants reported a lower prevalence of perceived physical health impacts during very hot days [93]. The relationship between heat and health risk is influenced by acclimatization and societal responses to heat [94–96]. It may be that economic immigrants, the majority of whom emigrated from areas with warmer climates relative to Edmonton [97], are accustomed to higher maximum temperatures and are better positioned to adapt both physically and behaviorally. Since economic immigrants are admitted to Canada on the basis of potential economic contribution, it may also be that they are healthier and more resilient in general. Further research is needed to explore the relationship between exposure to increased temperature and heat with injuries in immigrant populations.

Consistent with other studies [18,98], exposure to higher levels of industrial emissions was a risk factor for injuries at the DA level. The adverse effects of greater exposure to industrial emissions appear to counteract the community-level protective effect of higher proportions of immigrants and amplify the risk associated with higher proportions of refugees. A Canadian study exploring disparities in air pollution exposure observed high proportions of immigrant and racialized residents in areas with higher cumulative air pollution scores from traffic and industrial-related pollutants in Montreal [99]. Material deprivation also exhibited a strong positive association with adverse health events in this study. Environmental justice literature indicates low SES communities are also exposed to higher levels of air pollution that adversely impact their health [100]. As such, further research around the intersection between immigrants, material deprivation, and industrial emissions and the relationship this has with health is needed.

4.3.3 Mental health events

Although point estimates suggested increasing temperature and heat events were risk factors for mental health, results were not consistently significant. Literature suggests that mental health is directly impacted by higher temperatures in older persons and the general population [18,101], so it may be the existing small spatial differences in exposure across Edmonton did not have an observable effect, and it could also reflect healthcare seeking behavior. Exposure to higher levels of industrial emissions was a risk factor for mental health outcomes, which is consistent with findings in the literature [18,98]. There was also evidence for threshold effects since the adverse impact on health was only significant at higher proportions of immigrants. Like injuries, it may be that, due to colocation, immigrant populations live in areas where they are exposed to higher cumulative levels of these pollutants [99] resulting in adverse mental health impacts.

4.3.4 Respiratory health events

Increasing minimum temperature was a risk factor for higher rates of respiratory health events, although other measures of heat and temperature did not demonstrate significant associations. $PM_{2.5}$ exposure was also significant risk factor for higher rates of respiratory health events at the DA level. Respiratory health, in both the general population and older adults, has been shown to be directly impacted by higher temperatures and particulate matter [18,102–104]. The effects of diurnal temperature range (DTR) in this study were modified by the percentage of refugees in respiratory health models. This protective effect is only observed at lower percentages of refugees, while at higher percentages it was a risk factor. The origin countries of most refugees in Canada have warmer climates relative to Edmonton [97], which may suggest that increasing DTR poses a greater respiratory health risk to those already accustomed to smaller diurnal temperature changes and warmer climates. Different aeroallergen profiles between origin and host countries may also influence risks [105].

4.4 STRENGTHS AND LIMITATIONS

A strength of this study is that it included almost all the population within the study area, reducing the risk of selection bias. Adaptation initiatives can and will occur at multiple levels. This study contributes to our current understanding of what drives community health impacts in older adults and immigrant communities. These findings can help inform future vulnerability and health risk assessments

and the development of locally relevant health surveillance systems for monitoring and protecting the health of groups of people living in Edmonton.

This study had some limitations that are important to address. The degree of association observed between climate- and air pollution-related variables and adverse health impacts at the ecological level may differ when assessed using individual-level data. Behavioural factors that influence the health outcomes in this study, such as smoking, were not captured as data were not available at the DA level. The modifiable areal unit problem, or aggregation bias, is also a consideration in this study, as the population densities and health event rates are influenced by the shape and scale of the aggregation unit. Since spatial autocorrelation was not accounted for, this may lead to an overestimation of significance in analysis. Analyses were also limited by data availability. Briefly, 1,126 (94%) of 1,196 DAs in Edmonton were included due to a lack of people residing in some of these areas and missing independent variables data. LURs for O_3 and NO_2 were only available for the years 2015 and 2015-2016, respectively. While LUR estimates for $PM_{2.5}$, NO_2, and O_3, correlated highly with monitor data in cross-validations (R^2=0.92, 0.73, 0.91, respectively), there is still the potential for exposure misclassification. Furthermore postal codes do not capture individual time-activity patterns. Measures of minimum, maximum, and mean temperature, diurnal temperature change, heat events, and total precipitation were also limited to data from 2015, though were broadly consistent with stationary monitor data trends between 2015 and 2018, inclusive. Higher precision hazard exposure data from CANUE was used where possible despite the limited years due to the placement and a small number of monitors within the city limiting the accuracy of concurrent exposures (Appendix 4).

5 CONCLUSION

Climate change and air pollution pose a significant risk to human health that manifests when existing vulnerability converges with exposure to related hazards. This study found a greater proportion of older adults were at risk for climate- and air pollution-related health effects, supporting previous literature that indicates older adults may face increased risk within the context of a changing climate. Effects differ between subgroups of immigrants; areas with higher proportions of economic immigrants demonstrated decreased health risk while areas with higher proportions of refugees demonstrated increased health risk at the DA level. Based on these findings, further research investigating the health impacts of climate and air pollution hazards between subgroups of immigrants is warranted. Local socioecological explorations will be critical in informing meaningful approaches to reduce the health

impacts of climate change and air pollution. These results contribute to this ongoing work in Canada, and elsewhere.

ACKNOWLEDGEMENTS

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Chapter 4: Discussion and Conclusion

Climate change and air pollution are global problems with local impacts. These interrelated environmental phenomena have been identified as significant threats to public health on a global scale, but the nature and magnitude of the health impacts also depends on location [1–6]. The rate of warming in Canada is double the global average, and residents are already experiencing the adverse effects of climate change-related changes in weather and air pollution on health, which will be exacerbated as the climate continues to change [5–8]. The growing older adult and immigrant populations in Canada may bear a disproportionate burden of the health impacts due to several factors that could increase their risks and limit their coping capacity [9–13]. Adaptation strategies aimed at protecting the health of these populations, informed by an understanding of community-level vulnerabilities to local hazards, has emerged as an approach that can highlight and help meet the needs communities with distinct physical and social characteristics [2]. This thesis explored health risks and resilience associated with climate change and air pollution in older adults and immigrants living in Canada, and specifically in Edmonton, AB.

1 SUMMARY OF THESIS FINDINGS

In Chapter 2, a scoping review synthesized evidence from literature published between 2009 to June 2020 on the health impacts of climate change and air pollution in Canadian older adults and immigrants. Information on immigrants was scarce. Results suggested older adults in Canada experience health risks when exposed to climate- and air pollution-related hazards, although the magnitude of the differences between older and younger adults remains unclear.

In many cases, differences in age effects were outcome-specific and dependent on contextual factors. In older adults, region of residence and population density affected health vulnerability to hazards associated with climate change and air pollution, as did intersecting identities and circumstances (e.g. age, sex, low socioeconomic status (SES), poor health status). For example, low socioeconomic status (SES) in older adults often increased the risk of adverse health events linked to climate change and air pollution. Fewer studies explored social and behavioural factors in older adults that may promote or reduce resilience to adverse health impacts in our changing climate, but they likely play an important role.

Chapter 3 aimed to address knowledge gaps identified in Chapter 2 through an ecological correlation study exploring how community-level characteristics affect health vulnerability to climate change, focusing on older adults and immigrants in Edmonton, Alberta. The Intergovernmental Panel on Climate Change Fifth Assessment Report (IPCC AR5) risk framework was used to guide investigations in terms of exposure to climate hazards and vulnerability [6]. This chapter found that the per capita rates of climate-sensitive health events (i.e. cardiovascular, injury, mental, and respiratory) at the DA level were associated with a number of hazards related to climate change and air pollution (increasing temperature and heat events, diurnal temperature range (DTR), precipitation, $PM_{2.5}$, O_3, NO_2, and industrial emissions). As expected, increasing average age and higher proportions of older adults were associated with increased risk of health events in these relationships, regardless of the health outcome. In some cases, increasing age modified the effect of a hazard on community-level health; for example, precipitation and O_3 were associated with a greater risk of injuries with higher percentages of people ≥65 years.

Results also pointed towards the diversity among immigrants in Edmonton. Higher proportions of economic immigrants (admitted to Canada on the basis of potential economic contribution) were associated with decreased health risk, while higher proportions of refugees were associated increased health risk. In some instances, the proportion of economic immigrants modified the effects of temperature related variables (e.g., maximum temperature, DTR) such that adverse effects were attenuated. This may indicate differences in heat tolerance between Canadian- and foreign-born residents since most immigrants in Canada emigrate from countries with warmer climates. Conversely, the results implied that the adverse health effects of greater exposure to industrial emissions counteracted the protective health effect of higher fractions of economic immigrants and amplified the risk associated with higher proportions of refugees.

Both material and social deprivation were strongly associated with health risk at the community-level in fully adjusted hazard models, while greater access to greenspace and a more favorable Active Living Environment (ALE) tended to be protective. The results for the effect of greater health and social service access were unexpected. While not significant in all models, decreased spatial proximity to these services were associated with increased risk of adverse health effects at the community level. However, proximity may not accurately reflect access and utilization of these services. Findings provided insight into community-level health vulnerability to climate change and air pollution in Edmonton by identifying

potential indicators of sensitivity (age, immigrant status, sex, material and social deprivation) and adaptive capacity (greenspace, ALE, health and social service access).

2   CONTRIBUTIONS AND GAPS

Findings in Chapter 3 at the community-level were broadly consistent with the Canadian literature on health impacts of climate change and air pollution in older adults identified in Chapter 2. In both, evidence suggests that older adult communities face significant health risk but is not a 'one size fit all' risk within the context of climate change and air pollution. Findings indicate that socioeconomic status, social support, and environmental characteristics (e.g., greenspace, population density) likely influence how health impacts manifest at the community-level. However, unexplored dynamics characterizing current sensitivity and adaptive capacity in older adults remain.

With respect to immigrants, there is very little literature in looking at climate change, air pollution, and health in Canada. Chapter 2 identified a single study published between 2009 and June 2020 that explored the effect of air pollution on health and included immigrants; results found incident prostate cancer was higher in areas with more recent immigrants [14]. Findings of more recent work suggest that due to settlement patterns in urban areas, immigrants may face higher exposures to particulate matter [15,16] and experience stronger effects on mortality compared to Canadian-born individuals [15]. While Chapter 3 did not explore mortality as an outcome, findings from this work align with these studies. Industrial emissions had a greater adverse effect on health where there were higher proportions of immigrants, highlighting the possibility of colocation: immigrants in Edmonton live in areas with higher levels of air pollution. Only one study examining the perceived health impacts of heat in Canadian immigrants was identified in Chapter 2. The authors found those born outside Canada reported a lower prevalence of poor health during heat events relative Canadian-born populations [17], which aligns with results in Chapter 3. A threshold effect demonstrated maximum temperature did not have a significant effect on the rate of injuries where there were higher proportions of economic immigrants, which could be related to the healthy migrant effect. To our knowledge, the work in Chapter 3 is among the first to address how Canadian immigrant communities' health may be impacted by climate change hazards.

3   INSIGHTS, IMPLICATIONS, AND FUTURE DIRECTIONS

The health impacts of climate change and air pollution, given our current global situation, are only expected to worsen. Since one-in-five of those living in Canada are immigrants [18], the lack of literature surrounding immigrant health in this context represents a substantial gap in the literature that needs to be addressed. Opportunities for future work also include establishing how older adults differ from younger adults in climate- and air pollution-health relationships and refining our understanding of how behavioural, social, and environmental factors influence risk and resiliency. It is important that these questions are explored across the diverse geographies in Canada since hazards and resources will differ, especially as the majority of existing Canadian literature describes populations in Quebec and Ontario.

Within an increasingly diverse Canadian population, considering intersectionality in future work will help promote understanding of how indicators of sensitivity and adaptive capacity interact to attenuate or amplify health-related vulnerability. Studies have found that older immigrant women in Canada tend to underutilize preventative health services, experience more difficulties accessing healthcare, and have more health problems compared to Canadian-born women [19]. Research in other higher income countries has also demonstrated that sociodemographic and socioeconomic factors increasing vulnerability to extreme heat events within the general population are intensified within the immigrant population [20,21]. Similarly, comorbidity, social isolation, and low socioeconomic status in older people has been shown to increase the risk of adverse health events [8,22]. These will be particularly important considerations in addressing and preventing disproportionate climate change impacts in those who may be at greater risk due to intersecting identities (e.g., older adult, immigrant women).

Adaptation cannot completely remove the adverse health impacts of climate change. However, identifying how exposure to climate hazards drive health risk within the context of local environments can help inform strategies to protect health (e.g. reducing industrial emissions, cooling centers/air conditioning subsidies, community supports for racialized immigrants) in the near-term. Identifying and addressing sources of increased vulnerability, specifically, has been referred to as a 'no regrets policy [23].' This is because strengthening a system (e.g., communities, ecosystems, institutions) achieves "higher system performance" whether or not there is an immediate threat from climate change [23]. For example, promoting increased social participation and support may be an effective public health strategy, particularly for older adults [24,25], and directly responds to the adverse health effects of social deprivation observed in Chapter 3. In our changing climate, stakeholders, researchers, and decision makers should consider both intersectionality and socioecological contexts in future work to facilitate inclusive, equitable public health adaptation strategies.

4 CONCLUSION

This thesis was based on the assumption that human health is inseparable from social and environmental systems. Overall, the results support the growing body of evidence that indicates climate and air pollution related hazards pose a significant risk to human health, and that certain groups will likely bear a disproportionate burden. This work highlights existing health vulnerabilities, characterized by sensitivity and adaptive capacity, combined with exposure to local climate and air pollution hazards. Canadian literature indicates older adult health is at risk due to these hazards, but more work is needed to understand what affects this and where there are opportunities for effective adaptation. Evidence is lacking when it comes to understanding how these hazards impact the health of immigrants. The work from this thesis has contributed to the development of a climate-health index and mapping tool for Edmonton, AB to assist in community level planning activities targeted at reducing adverse health impacts. Future work will involve applying a similar strategy for the province of Alberta.

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Appendices

APPENDIX 1: SCOPING REVIEW PROTOCOL AND DETAILED SEARCH STRINGS

Characterizing sensitivity to climate change in older adults and immigrants in Canada– A scoping review protocol

1   Objective

The objective of this scoping review is to investigate the range, extent, and nature of published literature on the sensitivity to climate (extreme temperatures and events, icy conditions) and air pollution-related exposures in older adults and immigrants in Canada and the impact this has on health outcomes. The mapped literature will be used to inform public policy, guide adaptation and risk mitigation strategies, reduce health risks related to climate change and air pollution, and promote further research.

2   Research Questions

1. In Canada, what are the health-impacts of climate and air-pollution-related exposures in older adults and immigrants?
2. Are there socioeconomic characteristics that impact the relationship between these exposures and adverse health outcomes in these populations and what are they?

3   Methods

The scoping review will follow the framework outlined in the Joanna Briggs Institute Reviewer's Manual which includes identifying the research question and subsequently relevant studies, selecting studies, charting the data and reporting the results [1-6]. Reporting guidelines set by Tricco et al. in their scoping review extension of the PRISMA checklist will be followed [7]. The results of the review will be presented as a map of the data extracted in a tabular form and in a narrative descriptive summary.

3.1 Search Methods

3.1.1   Search Methods

A search was constructed and executed by an expert searcher/health librarian (SC) on the following databases: PROSPERO, OVID Medline, OVID EMBASE, OVID Global Health, OVID PsycInfo, Cochrane Library (CDSR and Central), EBSCO CINAHL, Proquest Dissertations and Theses Global and SCOPUS using controlled vocabulary (eg: MeSH, Emtree, etc) and key words representing the concepts "vulnerable poulations" and "climate change" and "health impacts" and "Canada" [8–14]. Databases were searched from inception or 2010 to June, 2020.   No other limits were applied. Results (3683) were exported to

COVIDENCE review management software. Duplicates (1141) were removed. Detailed search are available in Table A1.

3.1.2 Electronic Database Search

A comprehensive search string will be used to search the following databases:

a) Medline® covers worldwide journal literature in biomedical and health sciences;
b) Embase® is a medical database covering a wide range of biomedical science journals, with an emphasis on European studies not present in Medline;
c) CINAHL® plus covers topics including health promotion, professional issues for healthcare workers, patient care, patient education, and rehabilitation, among others;
d) Scopus® delivers literature related to medicine, technology, science and social sciences.
e) Environment Complete is a database for a wide range of topics pertain to environmental studies.

3.1.3 Snowball Search

A snowball search will be conducted on the reference lists of literature meeting the inclusion criteria to capture articles missed in the preliminary electronic database search.

3.1.4 Hand Search

Specific journals relevant to the focus topics will be manually searched for articles that are not captured in the database search.

4 Screening

4.1 Restrictions

- There will be no language restrictions in the search strings
- A date restriction will be placed on the search string. Literature published prior to 2010 will not be included.

4.2 Level 1 Screening

- A stacked questionnaire will be used to screen the titles and abstracts captured by the initial searches by two independent reviewers.
- If the article fully or partially meets the inclusion criteria (i.e. all screening questions are answered 'yes' or 'unsure'), the article will proceed to Level 2 screening.
- If the article meets any exclusion criteria it will not proceed to level 2 screening.
- A second independent reviewer will confirm exclusion of the article.

- Google Translate will be used to help screen non-English titles and abstracts.

4.3 Level 2 Screening

- Two independent reviewers will review the full article based on the inclusion and exclusion criteria.
- Only articles that meet all the inclusion criteria will be included in the review ('unsure' is not an option).

4.4 Inclusion Criteria

4.4.1 Note regardging inclusion criteria

The original search methods consisted of broader search strings that included older adults and immigrants in addition to other populations considered to be vulnerable to climate change (pregnant women, children, people experiencing homelessness, outdoor workers and Indigenous peoples) that was conducted for another project. The inclusion criteria for populations of interest in the current scoping review was narrowed to older adults and immigrants and literature concerning the other populations will be considered for future scoping reviews. Papers concerning older adults and immigrants were screened from included articles according to the following inclusion criteria.

4.4.2 Inclusion Criteria

This scoping review is a multidimensional investigation of vulnerability and will consider any research article that provides information related to the sensitivity of older adults and immigrants to adverse health outcomes due to exposure to climatic and air-pollution variables.

- All published articles will be examined regardless of the original language of publication.
- Only articles published in 2010 onward will be examined.
- We will only include research concerning older adults and immigrants in Canada since sensitivity to climatic and air pollution related exposures are highly influenced by specific environmental and socioeconomic contexts [15].
- Will include literature that investigates climate change related exposures and the health impacts this has on older adults and immigrants as primary points of interest:
  - o Climate change is defined as changes in climate that persist over decades or longer that can be due to natural or anthropogenic causes. Climatic variables, such as extreme temperatures and weather events, among others, will be included to capture literature that does not directly link these climatic variables to climate change.
  - o Vulnerability in this review is characterized by two axes

- Exposure to extreme events and/or other climatic variables (wildfires, floods, extreme temperatures, icy conditions, air pollution).
- Sensitivity resulting from individual and socioeconomic characteristics that influence exposure-related health impacts.
  - Vulnerable populations of interest in this review include older adults (≥65 years) and immigrants.

4.5 Exclusion Criteria

- Research investigating in areas outside of Canada will be excluded.

- Books, book chapters, theses, and dissertations will be excluded.

- Research that does not investigate climate and air-pollution related health impacts in relation to vulnerable populations of interest.
  - Research that describes health-related impacts that have been linked to climate and air-pollution exposures but are not in reference to older adults and immigrants.
  - Research on health-related impacts on older adults and immigrants, but without climatic or air pollution variables.
  - Research on climatic or air pollution variables but in the absence of health impacts.

4.6 Screening Questions

4.6.1 Level 1

The following questions will be answered using a stacked form to screen each title and/or abstract:

- Does the research focus on exposure to climatic variables (wildfires, floods, extreme temperatures, icy conditions) and air pollution?
  - Yes
  - No
  - Unsure
- Does the research focus on health-related impacts of climatic variables and air pollution?
  - Yes
  - No
  - Unsure
- Does the research focus on older adults and immigrants?
  - Yes
  - No

- o Unsure
- Does the research focus on Canada?
  - o Yes
  - o No
  - o Unsure
- Is it a journal article?
  - o Yes
  - o No
  - o Unsure

If 'yes' or 'unsure' is selected, confirm inclusions.

4.6.2 Level 2

The following questions will be answered after screening each full article:

- Does the research focus on exposure to climatic variables (extreme temperatures, icy conditions, erratic rain fall, and air pollution?
  - o Yes
  - o No
- Does the research focus on health-related impacts of climatic variables and air pollution?
  - o Yes
  - o No
- Does the research focus on older adults and immigrants?
  - o Yes
  - o No
- Does the research focus on Canada?
  - o Yes
  - o No

5 Data Collection and Analysis

5.1 Software

Covidence will be used to manage the scoping review. After uploading all eligible articles, the software will remove duplicates. Screening forms will be employed to determine eligibility.

6 References

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Table A1 Detailed search strings

Ovid MEDLINE(R) ALL <1946 to June 05, 2020>

#	Search Statement	Results
1	weather/ or Climate/ or climatic processes/ or ((exp climate change/ or cyclonic storms/ or droughts/ or floods/ or greenhouse effect/ or temperature/) and (precipitation or heat or cold or ambient or season* or climate or climatic or weather or summer or winter).ti,ab,kw.) or extreme heat/ or hot temperature/ or (((climat* not (political-climate or organizational-climate or economic-climate or financial-climate)) or weather) adj3 (chang* or disrupt* or volati* or instabilit* or unstable or variable or variability or vulnerab*)).ti,ab,kw. or ((chang* or decline* or decrease* or increase*) adj3 humidity).ti,ab,kw. or ((global* or climate) adj2 warm*).ti,ab,kw. or ((climat* or weather) adj (conditions or factors or driven)).ti,ab,kw. or (greenhouse gas* or greenhouse effect* or carbon emission* or carbon dioxide emission* or CO2 emission*).ti,ab,kw. or (((extreme or severe) adj (weather or heat or temperature*)) or hot-weather or heat-wave* or heatwave or high temperatures or ((higher or warm* or hot*) adj3 temperature*)).ti,ab,kw. or ((annual* or daily or month* or ambient or environmental or season* or climate or climatic or weather or summer or winter) adj4 temperature*).ti,ab,kw. or (warm-season* or warm*-month* or (unseasonabl* adj3 (warm or hot or heat or humid* or cold or high or low))).ti,ab,kw. or (El Nino or la nina).ti,ab,kw. or (rain or rains or rainstorm* or raining or rainfall or ((high or heavy or extreme or severe or daily or levels) adj2 precipitation) or UV-index or flooding or floods or waterlogging or (drought* not drought-resistan*) or desertifcation or hurricane* or cyclone* or tornado* or superstorm* or dust storm or storm surge* or ice storm* or ((storm or storms) and disaster*) or monsoon*).ti,ab,kw. or (forest fire* or wildfire* or wild fire* or fire disaster* or (uncontrolled adj3 fire*)).ti,ab,kw. or ((sea level* adj3 (rise or rises or rising or increase or increasing or increases)) or ((polar or permafrost or ice-cap or glacier*) adj3 (melt* or retreat* or reced* or thaw*))).ti,ab,kw. or famine*.ti,ab,kw.	345759
2	exp Air Pollution/ or Traffic-Related Pollution/ or greenhouse gases/ or stratospheric ozone/ or ((gases/ or ammonia/ or carbon dioxide/ or carbon monoxide/ or chlorine/ or greenhouse gases/ or hydrogen sulfide/ or nitrogen/ or nitrogen oxides/ or nitrogen dioxide/ or nitrous oxide/ or ozone/ or sulfur dioxide/ or carbon monoxide*.ti,ab,kw. or hydrogen sulfide*.ti,ab,kw. or hydrogen sulphide*.ti,ab,kw. or H2S.ti,ab,kw. or nitrogen oxide*.ti,ab,kw. or volatile organic*.ti,ab,kw. or voc.ti,ab,kw. or nox.ti,ab,kw. or sulfur dioxide*.ti,ab,kw. or	265335

	SO2.ti,ab,kw. or sulfur oxide*.ti,ab,kw. or sulphur dioxide*.ti,ab,kw. or sulphur oxide*.ti,ab,kw.) and (exp Pollution/ or pollut*.ti,ab,kw. or emit*.ti,ab,kw. or emission*.ti,ab,kw. or contaminat*.ti,ab,kw. or decontaminat*.ti,ab,kw.)) or ((air or atmospher*) adj3 (pollut* or quality or wast* or contamin* or emission* or immission* or effluent*or acidification or contaminat* or degrad* or decontaminat* or purif* or restor*)).ti,ab,kw. or ((gas or gases) adj3 (toxic* or noxious or releas* or purifi* or scrub* or emit* or waste* or vapo?r)).ti,ab,kw. or (acid* adj3 (deposition* or rain* or snow or fog or mist or precipitation or hail or sleet)).ti,ab,kw. or afterburning.ti,ab,kw. or biogas.ti,ab,kw. or (burning adj3 fossil fuel*).ti,ab,kw. or ((chimney or stack) adj3 height).ti,ab,kw. or dust.ti,ab,kw. or fallout.ti,ab,kw. or fall out.ti,ab,kw. or flaring.ti,ab,kw. or fly ash.ti,ab,kw. or electrosmog.ti,ab,kw. or (greenhouse adj3 (gas or effect or effects or gases or emission*)).ti,ab,kw. or incineration.ti,ab,kw. or odor.ti,ab,kw. or odour.ti,ab,kw. or olfactory pollution.ti,ab,kw. or particulate*.ti,ab,kw. or smog.ti,ab,kw. or smoke.ti,ab,kw. or soot.ti,ab,kw. or sick building syndrome.ti,ab,kw. or vapo?r recovery system*.ti,ab,kw. or ((industrial or automobile* or traffic or freeway or highway or roadway or motorway or diesel or vehicle*) adj3 (exhaust* or emission* or emit* or fume or fumes or vapo?r*)).ti,ab,kw.	
3	1 or 2	583895
4	(health* or disease* or outbreak* or infectio* or illness* or virus* or injur* or disorder* or epidemic* or pandemic* or fever* or symptoms).mp. or exp pregnancy complications/ or exp infant, Low Birth Weight/ or stillbirth/ or (deformit* or malformation* or cleft-palate* or cleft-lip* or birth-defect* or congenital heart defect* or spina-bifida or birth-outcome* or pregnancy-outcome* or still-birth or still-born* or stillborn or stillbirth* or low-birth-weight or (fetal-growth adj (restric* or retard*)) or preterm labo* or preterm birth or (hypertension and pregnan*) or preeclampsia).mp. or (((developmental* or intellectual* or learning or mental or cognitive or physical*) adj3 (disab* or impair* or delay* or disorder*)) or mental retard* or handicap* or special needs or down* syndrome or "fragile x" or autis* or asperger* or pervasive developmental disorder* or cerebral palsy or tourette* or tic-disorder* or attention-deficit* or adhd or epilep* or language-disorder* or neurodevelopment* or ((neuro or cognitive or physical*) adj5 development*)).mp. or stress, psychological/ or occupational stress/ or (stress-level* or high*-stress* or psychological-stress* or mental-stress* or burnout or psychiatric or depress* or anxiety or psychos* or stress-disorder* or PTSD or posttrauma* or trauma* or emotional-health).mp. or exp occupational diseases/ or (food-security or food-insecurity or nutrition or undernutrition or malnutrition or malnourish* or undernourish* or overnutrition or famine or food-availability or food-supply or ((nutrition* or	14810075

	vitamin) adj4 deficien*)).mp. or (underweight or thinness or overweight or obes*).mp. or exp diseases/ or exp food safety/ or dietary exposure/ or (food-safety or (food adj4 (contaminat* or poison*))).mp. or ((safe or clean or unsafe or contamina*) adj6 (drink* or potable) adj6 water).mp. or exp mortality/ or exp morbidity/ or pregnancy outcome/ or (mortalit* or death* or fatalit*).mp. or (respiratory or asthma* or allerg* or aeroallerg* or ((breathing or breathe) adj3 (issue* or problem* or difficult* or struggl* or trouble))).mp. or exp heat stress disorders/ or (heat-stress* or heat-exhaustion or heat-stroke* or heatstroke* or sun stroke* or sunstroke*).mp. or (cholera* or diarrhea* or diarrhoea* or dysentery or salmonella or pneumonia* or plasmodium* or babesi* or hantavirus* or giardia* or cryptosporidi* or leptospiros*).mp. or exp parasitic diseases/ or (Trichinos* or trichinellosis or Chikungunya or Dengue or Lymphatic-filariasis or Rift-Valley-fever or Yellow-fever or Zika or Malaria or japanese-encephalitis or tick-borne or West-Nile-fever or Leishmaniasis or Sandfly-fever or phelebotomus-fever or haemorrhagic-fever or Lyme-disease or Relapsing-fever or borreliosis or Rickettsial-diseases or spotted-fever or Q-fever or Tularaemia or Chagas or trypanosomiasis or Sleeping-sickness or Plague or Rickettsiosis or Onchocerciasis or river-blindness or Schistosomiasis or bilharziasis or Typhus or louse-borne-relapsing-fever).mp.	
5	(canad* or "british columbia" or alberta* or saskatchewan or manitoba* or ontario or quebec or (new brunswick not new jersey) or nouveau brunswick or nova scotia or nouvelle ecosse or prince edward island or newfoundland or labrador or nunavut or nwt or northwest territories or yukon or nunavik or inuvialuit).mp,jw,nw. or (Abbotsford or Airdrie or Ajax or Aurora or Barrie or Belleville or Blainville or Brampton or Brantford or Brossard or Burlington or Burnaby or Caledon or Calgary or Cape Breton or Chatham Kent or Chilliwack or Clarington or Coquitlam or Drummondville or Edmonton or Fredericton or Fort McMurray or Gatineau or Granby or Grande Prairie or Sudbury or Guelph or Halton Hills or Iqaluit or Inuvik or Kamloops or Kawartha Lakes or Kelowna or Kingston or Kitchener or Langley or Laval or Lethbridge or Levis or Longueuil or Maple Ridge or Markham or Medicine Hat or Milton or Mirabel or Mississauga or Moncton or Montreal or Nanaimo or New Westminster or Newmarket or Niagara Falls or Norfolk County or North Bay or North Vancouver or North Vancouver or Oakville or Oshawa or Ottawa or Peterborough or Pickering or Port Coquitlam or Prince George or Quebec City or Red Deer or Regina or Repentigny or Richmond or Richmond Hill or Saanich or Saguenay or Saint John or Saint-Hyacinthe or Saint-Jean-sur-Richelieu or Saint-Jerome or Sarnia or Saskatoon or Sault Ste Marie or Sherbrooke or St Albert or St Catharines or St John's or Strathcona County or Surrey or Terrebonne or Thunder Bay or Toronto or Trois-Rivieres or Vancouver or Vaughan or ((Cambridge or (Halifax or Hamilton or London or Victoria or Waterloo or Welland or Whitby or Windsor)) not (UK or Britain or United Kingdom or England or Australia)) or Whitehorse or Winnipeg or Wood Buffalo or	506769

	Yellowknife).ti,ab,kw.	
6	exp geriatrics/ or aged/ or aged hospital patient/ or exp elderly care/ or frail elderly/ or gerontology/ or institutionalized elderly/ or very elderly/ or ("aging in place" or elders or elderly or geriatric* or gerodontic* or old age or (seniors not "high school") or older adult* or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or "oldest old").mp.	3193728
7	exp Pregnancy Complications/ or exp Pregnancy/ or exp Pregnant Women/ or exp Labor, Obstetric/ or exp Delivery, Obstetric/ or exp Obstetric Labor, Premature/ or exp Obstetric Labor Complications/ or Prenatal Care/ or (obstetric* or prenatal* or pregnan* or gestat* or perinatal or antenatal or parturi* or childbirth or (labo?r adj3 delivery)).mp.	1196393
8	adolescent/ or exp child/ or child, preschool/ or infant/	3228982
9	child/ or child, abandoned/ or child, adopted/ or exp child, exceptional/ or "child of impaired parents"/ or child, foster/ or child, orphaned/ or child, unwanted/	1680252
10	(fetus* or fetal or foetus* or foetal* or "in utero" or pediatric* or paediatric* or child* or newborn* or congenital* or infan* or baby or babies or neonat* or pre term or preterm* or premature birth or NICU or preschool* or pre school* or kindergarten* or elementary school* or nursery school* or schoolchild* or toddler* or boy or boys or girl* or middle school* or pubescen* or juvenile* or teen* or youth* or high school* or adolesc* or prepubesc* or pre pubesc*).mp. or (child* or adolesc* or pediat* or paediat*).jn.	4774786
11	exp "Emigrants and Immigrants"/ or Refugees/ or (immigrant* or immigration or emigrant* or emigration or refugee* or asylum seeker* or asylee* or displaced person* or "incomer*" or "in comer*" or "new comer*" or newcomer* or migrant* or resettler*).mp.	83044
12	(exp Indians, North American/ or exp Inuits/ or exp Health Services, Indigenous/ or exp Ethnopharmacology/ or Athapaskan.mp. or Saulteaux.mp. or Wakashan.mp. or Cree.mp. or Dene.mp. or Inuit.mp. or Inuk.mp. or	7411

	Inuvialuit*.mp. or Haida.mp. or Ktunaxa.mp. or Tsimshian.mp. or Gitsxan.mp. or Nisga'a.mp. or Haisla.mp. or Heiltsuk.mp. or Oweenkeno.mp. or Kwakwaka'wakw.mp. or Nuu chah nulth.mp. or Tsilhqot'in.mp. or Dakelh.mp. or Wet'suwet'en.mp. or Sekani.mp. or Dunne-za.mp. or Dene.mp. or Tahltan.mp. or Kaska.mp. or Tagish.mp. or Tutchone.mp. or Nuxalk.mp. or Salish.mp. or Stl'atlimc.mp. or Nlaka'pamux.mp. or Okanagan.mp. or Sec wepmc.mp. or Tlingit.mp. or Anishinaabe.mp. or Blackfoot.mp. or Nakoda.mp. or Tasttine.mp. or Tsuu T'inia.mp. or Gwich'in.mp. or Han.mp. or Tagish.mp. or Tutchone.mp. or Algonquin.mp. or Nipissing.mp. or Ojibwa.mp. or Potawatomi.mp. or Innu.mp. or Maliseet.mp. or Mi'kmaq.mp. or Micmac.mp. or Passamaquoddy.mp. or Haudenosaunee.mp. or Cayuga.mp. or Mohawk.mp. or Oneida.mp. or Onodaga.mp. or Seneca.mp. or Tuscarora.mp. or Wyandot.mp. or Aboriginal*.mp. or Indigenous*.mp. or Metis.mp. or red road.mp. or "on reserve".mp. or off-reserve.mp. or First Nation.mp. or First Nations.mp. or Amerindian.mp. or (urban adj3 (Indian* or Native* or Aboriginal*)).mp. or ethnomedicine.mp. or country food*.mp. or residential school*.mp. or ((exp Medicine, Traditional/ or traditional medicine*.mp.) not Chinese.mp.) or exp Shamanism/ or shaman*.mp. or traditional heal*.mp. or traditional food*.mp. or medicine man.mp. or medicine woman.mp. or autochtone*.mp. or (Native* adj1 (man or men or women or woman or boy* or girl* or adolescent* or youth or youths or person* or adult or people* or Indian* or Nation or tribe* or tribal or band or bands)).mp.) and (exp Canada/ or (Canad* or British Columbia or Columbie Britannique or Alberta or Saskatchewan or Manitoba or Ontario or Quebec or Nova Scotia or New Brunswick or Newfoundland or Labrador or Prince Edward Island or Yukon Territory or NWT or Northwest Territories or Nunavut or Nunavik or Nunatsiavut or NunatuKavut).mp.)	
13	occupational exposure/ or ((agricultur* or forest* or farm* or field or fields) adj3 (work* or labo?*)).mp. or (((((arborist* or archaeologist* or fruit) adj3 picker*) or farm labo?r or berry pick* or cowboy* or cowgirl* or "deck hand" or dog walker* or farmworker* or fisher* worker* or fisherm?n or firefighter* or fire fighter* or farmer* or farmhand* or forester or flagm?n or flagwom?n or greens keeper* or grounds keeper* or gardener* or garbagewom* or (garbage adj3 (man or men or women or woman or collector* or worker*)) or herder* or hunter* or letter carrier* or lifeguard* or landscaper* or mail carrier* or marine biologist* or mariner* or ((outdoor* or outside or "out of doors") adj3 (work* or employment or construction* or job or jobs)) or playground supervisor* or power line technician* or ski instructor* or ski patrol* or ranger or rangers or "rig hand*" or sailor* or parks worker* or shepherd* or smoke jumper* or stoop labo?r* or trapper* or tree planter* or vegetable) adj3 picker*) or wildlife biologist*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary	83814

	concept word, rare disease supplementary concept word, unique identifier, synonyms]	
14	exp Homeless Persons/ or exp "Transients and Migrants"/ or ((vulnerable or migrant or transient*) adj2 (people or person* or individual* or child* or youth* or population* or worker* or men or women or man or woman)).mp. or (street adj2 (people or person* or individual* or youth* or population* or child* or men or women or man or woman)).mp. or ("lack of housing" or substandard housing or unstably housed or underhoused or under housed or squatter* or homeless* or vagrant* or indigent).mp. or (marginal* adj2 (population* or people* or group* or hous*)).mp.	58978
15	6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or Vulnerable Populations/	7939559
16	3 and 4 and 5 and 15	2299
17	Animals/ not (Animals/ and Humans/)	4671817
18	16 not 17	2202
19	(smoking or smoker* or "who smoke" or squirrel* or (newcastle adj2 ottawa)).mp.	313017
20	18 not 19	1487
21	remove duplicates from 20	1480
22	**limit 21 to yr="2010 -Current"**	**771**

#	Search Statement	Results
1	weather/ or Climate/ or climatic processes/ or ((exp climate change/ or cyclonic storms/ or droughts/ or floods/ or greenhouse effect/ or temperature/) and (ambient or season* or climate or climatic or weather or summer or winter).mp.) or extreme heat/ or hot temperature/ or (((climat* not (political-climate or organizational-climate or economic-climate or financial-climate)) or weather) adj3 (chang* or disrupt* or volati* or instabilit* or unstable or variable or variability or vulnerab*)).mp. or ((chang* or decline* or decrease* or increase*) adj3 humidity).mp. or ((global* or climate) adj2 warm*).mp. or ((climat* or weather) adj (conditions or factors or driven)).mp. or (greenhouse gas* or greenhouse effect* or carbon emission* or carbon dioxide emission* or CO2 emission*).mp. or (((extreme or severe) adj (weather or heat or temperature*)) or hot-weather or heat-wave* or heatwave or high temperatures or ((higher or warm* or hot*) adj3 temperature*)).mp. or ((annual* or daily or month* or ambient or environmental or season* or climate or climatic or weather or summer or winter) adj4 temperature*).mp. or (warm-season* or warm*-month* or (unseasonabl* adj3 (warm or hot or heat or humid* or cold or high or low))).mp. or (El Nino or la nina).mp. or (rain or rains or rainstorm* or raining or rainfall or ((high or heavy or extreme or severe or daily or levels) adj2 precipitation) or UV-index or flooding or floods or waterlogging or (drought* not drought-resistan*) or desertifcation or hurricane* or cyclone* or tornado* or superstorm* or dust storm or storm surge* or ice storm* or ((storm or storms) and disaster*) or monsoon*).mp. or (forest fire* or wildfire* or wild fire* or fire disaster* or (uncontrolled adj3 fire*)).mp. or ((sea level* adj3 (rise or rises or rising or increase or increasing or increases)) or ((polar or permafrost or ice-cap or glacier*) adj3 (melt* or retreat* or reced* or thaw*))).mp. or famine*.mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	302648
2	exp Air Pollution/ or Traffic-Related Pollution/ or greenhouse gases/ or stratospheric ozone/ or ((gases/ or ammonia/ or carbon dioxide/ or carbon monoxide/ or chlorine/ or greenhouse gases/ or hydrogen sulfide/ or nitrogen/ or nitrogen oxides/ or nitrogen dioxide/ or nitrous oxide/ or ozone/ or sulfur dioxide/ or carbon monoxide*.mp. or hydrogen sulfide*.mp. or hydrogen sulphide*.mp. or H2S.mp. or nitrogen oxide*.mp. or volatile organic*.mp. or voc.mp. or nox.mp. or sulfur dioxide*.mp. or SO2.mp. or sulfur oxide*.mp. or sulphur dioxide*.mp.	461442

or sulphur oxide*.mp.) and (exp Pollution/ or pollut*.mp. or emit*.mp. or emission*.mp. or contaminat*.mp. or decontaminat*.mp.)) or ((air or atmospher*) adj3 (pollut* or quality or wast* or contamin* or emission* or immission* or effluent*or acidification or contaminat* or degrad* or decontaminat* or purif* or restor*)).mp. or ((gas or gases) adj3 (toxic* or noxious or releas* or purifi* or scrub* or emit* or waste* or vapo?r)).mp. or (acid* adj3 (deposition* or rain* or snow or fog or mist or precipitation or hail or sleet)).mp. or afterburning.mp. or biogas.mp. or (burning adj3 fossil fuel*).mp. or ((chimney or stack) adj3 height).mp. or dust.mp. or fallout.mp. or fall out.mp. or flaring.mp. or fly ash.mp. or electrosmog.mp. or (greenhouse adj3 (gas or effect or effects or gases or emission*)).mp. or incineration.mp. or odor.mp. or odour.mp. or olfactory pollution.mp. or particulate*.mp. or smog.mp. or smoke.mp. or soot.mp. or sick building syndrome.mp. or vapo?r recovery system*.mp. or ((industrial or automobile* or traffic or freeway or highway or roadway or motorway or diesel or vehicle*) adj3 (exhaust* or emission* or emit* or fume or fumes or vapo?r*)).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]

3	1 or 2	705155
4	(health* or disease* or outbreak* or infectio* or illness* or virus* or injur* or disorder* or epidemic* or pandemic* or fever* or symptoms).mp. or exp pregnancy complications/ or exp infant, Low Birth Weight/ or stillbirth/ or (deformit* or malformation* or cleft-palate* or cleft-lip* or birth-defect* or congenital heart defect* or spina-bifida or birth-outcome* or pregnancy-outcome* or still-birth or still-born* or stillborn or stillbirth* or low-birth-weight or (fetal-growth adj (restric* or retard*)) or preterm labo* or preterm birth or (hypertension and pregnan*) or preeclampsia).mp. or (((developmental* or intellectual* or learning or mental or cognitive or physical*) adj3 (disab* or impair* or delay* or disorder*)) or mental retard* or handicap* or special needs or down* syndrome or "fragile x" or autis* or asperger* or pervasive developmental disorder* or cerebral palsy or tourette* or tic-disorder* or attention-deficit* or adhd or epilep* or language-disorder* or neurodevelopment* or ((neuro or cognitive or physical*) adj5 development*)).mp. or stress, psychological/ or occupational stress/ or (stress-level* or high*-stress* or psychological-stress* or mental-stress* or burnout or psychiatric or depress* or anxiety or psychos* or stress-disorder* or PTSD or posttrauma* or trauma* or emotional-health).mp. or exp occupational diseases/ or (food-security or food-insecurity or nutrition or undernutrition or malnutrition or malnourish* or undernourish* or overnutrition or famine or food-availability or food-supply or ((nutrition* or	24436370

	vitamin) adj4 deficien*)).mp. or (underweight or thinness or overweight or obes*).mp. or exp diseases/ or exp food safety/ or dietary exposure/ or (food-safety or (food adj4 (contaminat* or poison*))).mp. or ((safe or clean or unsafe or contamina*) adj6 (drink* or potable) adj6 water).mp. or exp mortality/ or exp morbidity/ or pregnancy outcome/ or (mortalit* or death* or fatalit*).mp. or (respiratory or asthma* or allerg* or aeroallerg* or ((breathing or breathe) adj3 (issue* or problem* or difficult* or struggl* or trouble))).mp. or exp heat stress disorders/ or (heat-stress* or heat-exhaustion or heat-stroke* or heatstroke* or sun stroke* or sunstroke*).mp. or (cholera* or diarrhea* or diarrhoea* or dysentery or salmonella or pneumonia* or plasmodium* or babesi* or hantavirus* or giardia* or cryptosporidi* or leptospiros*).mp. or exp parasitic diseases/ or (Trichinos* or trichinellosis or Chikungunya or Dengue or Lymphatic-filariasis or Rift-Valley-fever or Yellow-fever or Zika or Malaria or japanese-encephalitis or tick-borne or West-Nile-fever or Leishmaniasis or Sandfly-fever or phelebotomus-fever or haemorrhagic-fever or Lyme-disease or Relapsing-fever or borreliosis or Rickettsial-diseases or spotted-fever or Q-fever or Tularaemia or Chagas or trypanosomiasis or Sleeping-sickness or Plague or Rickettsiosis or Onchocerciasis or river-blindness or Schistosomiasis or bilharziasis or Typhus or louse-borne-relapsing-fever).mp.	
5	(exp Canada/ or ((canad* or "british columbia" or alberta* or saskatchewan or manitoba* or ontario or quebec or (new brunswick not new jersey) or nouveau brunswick or nova scotia or nouvelle ecosse or prince edward island or newfoundland or labrador or nunavut or nwt or northwest territories or yukon or nunavik or inuvialuit).mp. or (Abbotsford or Airdrie or Ajax or Aurora or Barrie or Belleville or Blainville or Brampton or Brantford or Brossard or Burlington or Burnaby or Caledon or Calgary or Cape Breton or Chatham Kent or Chilliwack or Clarington or Coquitlam or Drummondville or Edmonton or Fredericton or Fort McMurray or Gatineau or Granby or Grande Prairie or Sudbury or Guelph or Halton Hills or Iqaluit or Inuvik or Kamloops or Kawartha Lakes or Kelowna or Kingston or Kitchener or Langley or Laval or Lethbridge or Levis or Longueuil or Maple Ridge or Markham or Medicine Hat or Milton or Mirabel or Mississauga or Moncton or Montreal or Nanaimo or New Westminster or Newmarket or Niagara Falls or Norfolk County or North Bay or North Vancouver or North Vancouver or Oakville or Oshawa or Ottawa or Peterborough or Pickering or Port Coquitlam or Prince George or Quebec City or Red Deer or Regina or Repentigny or Richmond or Richmond Hill or Saanich or Saguenay or Saint John or Saint-Hyacinthe or Saint-Jean-sur-Richelieu or Saint-Jerome or Sarnia or Saskatoon or Sault Ste Marie or Sherbrooke or St Albert or St Catharines or St John's or Strathcona County or Surrey or Terrebonne or Thunder Bay or Toronto or Trois-Rivieres or Vancouver or Vaughan or (Cambridge or (Halifax or Hamilton or London or Victoria or Waterloo or Welland or Whitby or Windsor)) or Whitehorse or Winnipeg or Wood Buffalo or Yellowknife).ti,ab.)) not (UK or Britain or	347700

	United Kingdom or Scotland or US or United States or USA or India or New Zealand or England or Australia).mp.	
6	exp geriatrics/ or aged/ or aged hospital patient/ or exp elderly care/ or frail elderly/ or gerontology/ or institutionalized elderly/ or very elderly/ or ("aging in place" or elders or elderly or geriatric* or gerodontic* or old age or (seniors not "high school") or older adult* or centenarian* or nonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or overaged or "oldest old").mp.	3134257
7	juvenile/ or exp adolescent/ or exp child/ or exp postnatal development/ or (pediatric* or paediatric* or child* or newborn* or congenital* or infan* or baby or babies or neonat* or pre term or preterm* or premature birth or NICU or preschool* or pre school* or kindergarten* or elementary school* or nursery school* or schoolchild* or toddler* or boy or boys or girl* or middle school* or pubescen* or juvenile* or teen* or youth* or high school* or adolesc* or prepubesc* or pre pubesc*).mp. or (child* or adolesc* or pediat* or paediat*).jn.	4672129
8	(fetus* or fetal or foetus* or foetal* or "in utero").mp.	506496
9	exp Refugees/ or (immigrant* or immigration or emigrant* or emigration or refugee* or asylum seeker* or asylee* or displaced person* or "incomer*" or "in comer*" or "new comer*" or newcomer* or migrant* or resettler*).mp.	80156
10	exp Indians, North American/ or exp Inuits/ or exp Health Services, Indigenous/ or exp Ethnopharmacology/ or Athapaskan.mp. or Saulteaux.mp. or Wakashan.mp. or Cree.mp. or Dene.mp. or Inuit.mp. or Inuk.mp. or Inuvialuit*.mp. or Haida.mp. or Ktunaxa.mp. or Tsimshian.mp. or Gitsxan.mp. or Nisga'a.mp. or Haisla.mp. or Heiltsuk.mp. or Oweenkeno.mp. or Kwakwaka'wakw.mp. or Nuu chah nulth.mp. or Tsilhqot'in.mp. or Dakelh.mp. or Wet'suwet'en.mp. or Sekani.mp. or Dunne-za.mp. or Dene.mp. or Tahltan.mp. or Kaska.mp. or Tagish.mp. or Tutchone.mp. or Nuxalk.mp. or Salish.mp. or Stl'atlimc.mp. or Nlaka'pamux.mp. or Okanagan.mp. or Sec wepmc.mp. or Tlingit.mp. or Anishinaabe.mp. or Blackfoot.mp. or Nakoda.mp. or Tasttine.mp. or Tsuu T'inia.mp. or Gwich'in.mp. or Han.mp. or Tagish.mp. or Tutchone.mp. or Algonquin.mp. or Nipissing.mp. or Ojibwa.mp. or Potawatomi.mp. or Innu.mp. or Maliseet.mp. or Mi'kmaq.mp. or Micmac.mp. or Passamaquoddy.mp. or Haudenosaunee.mp. or Cayuga.mp. or Mohawk.mp. or Oneida.mp. or Onodaga.mp. or Seneca.mp. or Tuscarora.mp. or Wyandot.mp. or Aboriginal*.mp. or Indigenous*.mp. or Metis.mp. or red road.mp. or "on reserve".mp. or off-reserve.mp. or First Nation.mp. or First Nations.mp. or Amerindian.mp. or (urban adj3 (Indian*	157314

	or Native* or Aboriginal*)).mp. or ethnomedicine.mp. or country food*.mp. or residential school*.mp. or ((exp Medicine, Traditional/ or traditional medicine*.mp.) not Chinese.mp.) or exp Shamanism/ or shaman*.mp. or traditional heal*.mp. or traditional food*.mp. or medicine [man.mp](man.mp). or medicine woman.mp. or autochtone*.mp. or (Native* adj1 (man or men or women or woman or boy* or girl* or adolescent* or youth or youths or person* or adult or people* or Indian* or Nation or tribe* or tribal or band or bands)).mp.	
11	occupational exposure/ or ((agricultur* or forest* or farm* or field or fields) adj3 (work* or labo?*)).mp. or (((((arborist* or archaeologist* or fruit) adj3 picker*) or farm labo?r or berry pick* or cowboy* or cowgirl* or "deck hand" or dog walker* or farmworker* or fisher* worker* or fisherm?n or firefighter* or fire fighter* or farmer* or farmhand* or forester or flagm?n or flagwom?n or greens keeper* or grounds keeper* or gardener* or garbagewom* or (garbage adj3 (man or men or women or woman or collector* or worker*)) or herder* or hunter* or letter carrier* or lifeguard* or landscaper* or mail carrier* or marine biologist* or mariner* or ((outdoor* or outside or "out of doors") adj3 (work* or employment or construction* or job or jobs)) or playground supervisor* or power line technician* or ski instructor* or ski patrol* or ranger or rangers or "rig hand*" or sailor* or parks worker* or shepherd* or smoke jumper* or stoop labo?r* or trapper* or tree planter* or vegetable) adj3 picker*) or wildlife biologist*).mp. [mp=title, abstract, heading word, drug trade name, original title, device manufacturer, drug manufacturer, device trade name, keyword, floating subheading word, candidate term word]	126194
12	exp Homelessness/ or exp "Transients and Migrants"/ or ((vulnerable or migrant or transient*) adj2 (people or person* or individual* or child* or youth* or population* or worker* or men or women or man or woman)).mp. or (street adj2 (people or person* or individual* or youth* or population* or child* or men or women or man or woman)).mp. or (hard to house or lack of housing or substandard housing or unstably housed or underhoused or under housed or squatter* or homeless* or vagabond* or vagrant* or indigent).mp. or (marginal* adj2 (population* or people* or group* or hous*)).mp.	104231
13	6 or 7 or 8 or 9 or 10 or 11 or 12 or At Risk Population/	7908515
14	3 and 4 and 5 and 13	2330

15	(smoker* or smoking or "who smoke" or squirrel*).mp.	501238
16	exp animal/	25601944
17	exp human/	20966613
18	16 and 17	20966613
19	16 not 18	4635331
20	15 or 19	5123836
21	14 not 20	1518
22	remove duplicates from 21	1500
23	limit 22 to yr="2010 -Current"	921

Global Health <1910 to 2020 Week 22>

#	Search Statement	Results
1	(Arctic amplification or Arctic shrinkage or carbon footprint or carbon offset or carbon sequestration or carbon sink or carbon sinks or (chlorofluorocarbon* adj2 (release or concentration* or atmosphere*)) or (climate adj2 (change* or model?ing or predict* or resilience or sensitivity)) or deglaciation or desertification or disaster risk* or drought or (earth adj2 warming) or El Nino or La Nina or emissions reduc* or emissions trading or ((glacial or glacier) adj3 (retreat* or melt*)) or global radiation or global temperature* or global warming or greenhouse effect or greenhouse gas or heat wave* or ice cap melt* or ice mass	196319

	loss* or Kyoto Protocol or (ozone adj2 hole) or Paris Accord or permafrost melt* or polar amplification or polar ice melt* or sea ice shrinkage or sea level rise* or sea surface warming or thermohaline circulation or ((extreme or severe) adj2 (temperature* or weather* or storm*)) or wildfire* or (ambient or season* or climate or climatic or weather or summer or winter or (((climat* not (political-climate or organizational-climate or economic-climate or financial-climate)) or weather) adj3 (chang* or disrupt* or volati* or instabilit* or unstable or variable or variability or vulnerab*)) or ((chang* or decline* or decrease* or increase*) adj3 humidity) or ((global* or climate) adj2 warm*) or ((climat* or weather) adj (conditions or factors or driven)) or (greenhouse gas* or greenhouse effect* or carbon emission* or carbon dioxide emission* or CO2 emission*) or (((extreme or severe) adj (weather or heat or temperature*)) or hot-weather or heat-wave* or heatwave or high temperatures or ((higher or warm* or hot*) adj3 temperature*)) or ((annual* or daily or month* or ambient or environmental or season* or climate or climatic or weather or summer or winter) adj4 temperature*) or (warm-season* or warm*-month* or (unseasonabl* adj3 (warm or hot or heat or humid* or cold or high or low))) or (El Nino or la nina) or (rain or rains or rainstorm* or raining or rainfall or ((high or heavy or extreme or severe or daily or levels) adj2 precipitation) or UV-index or flooding or floods or waterlogging or (drought* not drought-resistan*) or desertifcation or hurricane* or cyclone* or tornado* or superstorm* or dust storm or storm surge* or ice storm* or ((storm or storms) and disaster*) or monsoon*) or (forest fire* or wildfire* or wild fire* or fire disaster* or (uncontrolled adj3 fire*)) or ((sea level* adj3 (rise or rises or rising or increase or increasing or increases)) or ((polar or permafrost or ice-cap or glacier*) adj3 (melt* or retreat* or reced* or thaw*))) or famine*)).mp.	
2	(((carbon monoxide* or hydrogen sulfide* or hydrogen sulphide* or H2S or nitrogen oxide* or volatile organic* or voc or nox or sulfur dioxide* or SO2 or sulfur oxide* or sulphur dioxide* or sulphur oxide*) and (pollut* or emit* or emission* or contaminat* or decontaminat*)) or ((air or atmospher*) adj3 (pollut* or quality or wast* or contamin* or emission* or immission* or effluent*or acidification or contaminat* or degrad* or decontaminat* or purif* or restor*)) or ((gas or gases) adj3 (toxic* or noxious or releas* or purifi* or scrub* or emit* or waste* or vapo?r)) or (acid* adj3 (deposition* or rain* or snow or fog or mist or precipitation or hail or sleet)) or afterburning or biogas or (burning adj3 fossil fuel*) or ((chimney or stack) adj3 height) or dust or fallout or fall out or flaring or fly ash or electrosmog or (greenhouse adj3 (gas or effect or effects or gases or emission*)) or incineration or odor or odour or olfactory pollution or particulate* or smog or smoke or soot or sick building syndrome or vapo?r recovery system* or ((industrial or automobile* or traffic or freeway or highway or roadway or motorway or diesel or vehicle*) adj3 (exhaust* or emission* or emit* or fume or fumes or vapo?r*))).mp.	92762
3	1 or 2	268949

4	((canad* or "british columbia" or alberta* or saskatchewan or manitoba* or ontario or quebec or (new brunswick not new jersey) or nouveau brunswick or nova scotia or nouvelle ecosse or prince edward island or newfoundland or labrador or nunavut or nwt or northwest territories or yukon or nunavik or inuvialuit).mp. or (Abbotsford or Airdrie or Ajax or Aurora or Barrie or Belleville or Blainville or Brampton or Brantford or Brossard or Burlington or Burnaby or Caledon or Calgary or Cape Breton or Chatham Kent or Chilliwack or Clarington or Coquitlam or Drummondville or Edmonton or Fredericton or Fort McMurray or Gatineau or Granby or Grande Prairie or Sudbury or Guelph or Halton Hills or Iqaluit or Inuvik or Kamloops or Kawartha Lakes or Kelowna or Kingston or Kitchener or Langley or Laval or Lethbridge or Levis or Longueuil or Maple Ridge or Markham or Medicine Hat or Milton or Mirabel or Mississauga or Moncton or Montreal or Nanaimo or New Westminster or Newmarket or Niagara Falls or Norfolk County or North Bay or North Vancouver or North Vancouver or Oakville or Oshawa or Ottawa or Peterborough or Pickering or Port Coquitlam or Prince George or Quebec City or Red Deer or Regina or Repentigny or Richmond or Richmond Hill or Saanich or Saguenay or Saint John or Saint-Hyacinthe or Saint-Jean-sur-Richelieu or Saint-Jerome or Sarnia or Saskatoon or Sault Ste Marie or Sherbrooke or St Albert or St Catharines or St John's or Strathcona County or Surrey or Terrebonne or Thunder Bay or Toronto or Trois-Rivieres or Vancouver or Vaughan or (Cambridge or (Halifax or Hamilton or London or Victoria or Waterloo or Welland or Whitby or Windsor)) or Whitehorse or Winnipeg or Wood Buffalo or Yellowknife).ti,ab.) not (UK or Britain or United Kingdom or Scotland or US or United States or USA or India or New Zealand or England or Australia).mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	54599
5	(elders or elderly or geriatric* or old age or oldest age* or (seniors not "high school") or old* adult* or oldest patient* or "old old" or "very old" or centenarian* ornonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepit or tottering or late life or overaged or "oldest old").mp.	77452
6	(pediatric* or paediatric* or child* or newborn* or congenital* or infan* or baby or babies or neonat* or pre term or preterm* or premature birth or NICU or preschool* or pre school* or kindergarten* or elementary school* or nursery school* or schoolchild* or toddler* or boy or boys or girl* or middle school* or pubescen* or juvenile* or teen* or youth* or high school* or adolesc* or prepubesc* or pre pubesc*).mp. or (child* or adolesc* or pediat* or paediat*).jn.	616443
7	(fetus* or fetal or foetus* or foetal* or "in utero").mp.	45295
8	(immigrant* or immigration or emigrant* or emigration or refugee* or asylum seeker* or asylee* or displaced person* or	26468

	"incomer*" or "in comer*" or "new comer*" or newcomer* or migrant* or resettler*).mp.	
9	(Athapaskan or Saulteaux or Wakashan or Cree or Dene or Inuit or Inuk or Inuvialuit* or Haida or Ktunaxa or Tsimshian or Gitsxan or Nisga'a or Haisla or Heiltsuk or Oweenkeno or Kwakwaka'wakw or Nuu chah nulth or Tsilhqot'in or Dakelh or Wet'suwet'en or Sekani or Dunne-za or Dene or Tahltan or Kaska or Tagish or Tutchone or Nuxalk or Salish or Stl'atlimc or Nlaka'pamux or Okanagan or Sec wepmc or Tlingit or Anishinaabe or Blackfoot or Nakoda or Tasttine or Tsuu T'inia or Gwich'in or Han or Tagish or Tutchone or Algonquin or Nipissing or Ojibwa or Potawatomi or Innu or Maliseet or Mi'kmaq or Micmac or Passamaquoddy or Haudenosaunee or Cayuga or Mohawk or Oneida or Onodaga or Seneca or Tuscarora or Wyandot or Aboriginal* or Indigenous* or Metis or red road or "on reserve" or off-reserve or First Nation or First Nations or Amerindian or (urban adj3 (Indian* or Native* or Aboriginal*)) or ethnomedicine or country food* or residential school*).mp. or ((exp Medicine, Traditional/ or traditional medicine*.mp.) not Chinese.mp.) or exp Shamanism/ or shaman*.mp. or traditional heal*.mp. or traditional food*.mp. or medicine man.mp. or medicine woman.mp. or autochtone*.mp. or (Native* adj1 (man or men or women or woman or boy* or girl* or adolescent* or youth or youths or person* or adult or people* or Indian* or Nation or tribe* or tribal or band or bands)).mp.	112174
10	(((agricultur* or forest* or farm* or field or fields) adj3 (work* or labo?*)) or (arborist* or archaeologist* or (fruit adj3 picker*) or farm labo?r or berry pick* or cowboy* or cowgirl* or "deck hand" or dog walker* or farmworker* or fisher* worker* or fisherm?n or firefighter* or fire fighter* or farmer* or farmhand* or forester or flagm?n or flagwom?n or greens keeper* or grounds keeper* or gardener* or garbagewom* or (garbage adj3 (man or men or women or woman or collector* or worker*)) or herder* or hunter* or letter carrier* or lifeguard* or landscaper* or mail carrier* or marine biologist* or mariner* or ((outdoor* or outside or "out of doors") adj3 (work* or employment or construction* or job or jobs)) or playground supervisor* or power line technician* or ski instructor* or ski patrol* or ranger or rangers or "rig hand*" or sailor* or parks worker* or shepherd* or smoke jumper* or stoop labo?r* or trapper* or tree planter* or (vegetable adj3 picker*) or wildlife biologist*)).mp. [mp=abstract, title, original title, broad terms, heading words, identifiers, cabicodes]	49074
11	(((vulnerable or migrant or transient*) adj2 (people or person* or individual* or child* or youth* or population* or worker* or men or women or man or woman)) or (street adj2 (people or person* or individual* or youth* or population* or child* or men or women or man or woman)) or ("hard to houseor lack of housing" or "substandard housing" or "unstably housed" or underhoused or "under housed" or squatter* or homeless* or vagabond* or vagrant* or indigent) or (marginal* adj2 (population* or people* or group* or hous*))).mp.	14107

12	5 or 6 or 7 or 8 or 9 or 10 or 11	863988
13	3 and 4 and 12	1724
14	(smoker* or smoking or "who smoke" or dog or dogs or cat or cats or squirrel* or ungulate* or deer or boar or ((Newcastle adj2 Ottawa) or "mating season" or "C/victoria" or "B/victoria" or (yamagata adj5 victoria))).mp.	178824
15	13 not 14	1341
16	remove duplicates from 15	1335
17	limit 1	648

APA PsycInfo <1806 to June Week 1 2020>6 to yr="2010 - 2020"

#	Search Statement	Results
1	environmental effects/ or atmospheric conditions/ or seasonal variations/ or exp temperature effects/ or climate/ or climate change/ or cold climate/ or deglaciation/ or el nino/ or global climate/ or north atlantic oscillation/ or thermohaline circulation/ or greenhouse effect/ or exp greenhouse gas/ or Arctic amplification.mp. or Arctic shrinkage.mp. or carbon footprint.mp. or carbon offset.mp. or carbon sequestration.mp. or carbon sink.mp. or carbon sinks.mp. or (chlorofluorocarbon* adj2 (release or concentration* or atmosphere*)).mp. or (climate adj2 (change* or model?ing or predict* or resilience or sensitivity)).mp. or deglaciation.mp. or desertification.mp. or disaster risk*.mp. or drought.mp. or (earth adj2 warming).mp. or El Nino.mp. or La Nina.mp. or emissions reduc*.mp. or emissions trading.mp. or ((glacial or glacier) adj3 (retreat* or melt*)).mp. or global radiation.mp. or	22476

	global temperature*.mp. or global warming.mp. or greenhouse effect.mp. or greenhouse gas.mp. or heat wave*.mp. or ice cap melt*.mp. or ice mass loss*.mp. or Kyoto Protocol.mp. or (ozone adj2 hole).mp. or Paris Accord.mp. or permafrost melt*.mp. or polar amplification.mp. or polar ice melt*.mp. or sea ice shrinkage.mp. or sea level rise*.mp. or sea surface warming.mp. or thermohaline circulation.mp. or ((extreme or severe) adj2 (temperature* or weather* or storm*)).mp. or wildfire*.mp.	
2	(((carbon monoxide* or hydrogen sulfide* or hydrogen sulphide* or H2S or nitrogen oxide* or volatile organic* or voc or nox or sulfur dioxide* or SO2 or sulfur oxide* or sulphur dioxide* or sulphur oxide*) and (pollut* or emit* or emission* or contaminat* or decontaminat*)) or ((air or atmospher*) adj3 (pollut* or quality or wast* or contamin* or emission* or immission* or effluent*or acidification or contaminat* or degrad* or decontaminat* or purif* or restor*)) or ((gas or gases) adj3 (toxic* or noxious or releas* or purifi* or scrub* or emit* or waste* or vapo?r)) or (acid* adj3 (deposition* or rain* or snow or fog or mist or precipitation or hail or sleet)) or afterburning or biogas or (burning adj3 fossil fuel*) or ((chimney or stack) adj3 height) or dust or fallout or fall out or flaring or fly ash or electrosmog or (greenhouse adj3 (gas or effect or effects or gases or emission*)) or incineration or odor or odour or olfactory pollution or particulate* or smog or smoke or soot or sick building syndrome or vapo?r recovery system* or ((industrial or automobile* or traffic or freeway or highway or roadway or motorway or diesel or vehicle*) adj3 (exhaust* or emission* or emit* or fume or fumes or vapo?r*))).mp.	23433
3	1 or 2	44930
4	((canad* or "british columbia" or alberta* or saskatchewan or manitoba* or ontario or quebec or (new brunswick not new jersey) or nouveau brunswick or nova scotia or nouvelle ecosse or prince edward island or newfoundland or labrador or nunavut or nwt or northwest territories or yukon or nunavik or inuvialuit).mp. or (Abbotsford or Airdrie or Ajax or Aurora or Barrie or Belleville or Blainville or Brampton or Brantford or Brossard or Burlington or Burnaby or Caledon or Calgary or Cape Breton or Chatham Kent or Chilliwack or Clarington or Coquitlam or Drummondville or Edmonton or Fredericton or Fort McMurray or Gatineau or Granby or Grande Prairie or Sudbury or Guelph or Halton Hills or Iqaluit or Inuvik or Kamloops or Kawartha Lakes or Kelowna or Kingston or Kitchener or Langley or Laval or Lethbridge or Levis or Longueuil or Maple Ridge or Markham or Medicine Hat or Milton or Mirabel or Mississauga or Moncton or Montreal or Nanaimo or New Westminster or Newmarket or Niagara Falls or Norfolk County or North Bay or North Vancouver or North Vancouver or Oakville or Oshawa or Ottawa or	83388

	Peterborough or Pickering or Port Coquitlam or Prince George or Quebec City or Red Deer or Regina or Repentigny or Richmond or Richmond Hill or Saanich or Saguenay or Saint John or Saint-Hyacinthe or Saint-Jean-sur-Richelieu or Saint-Jerome or Sarnia or Saskatoon or Sault Ste Marie or Sherbrooke or St Albert or St Catharines or St John's or Strathcona County or Surrey or Terrebonne or Thunder Bay or Toronto or Trois-Rivieres or Vancouver or Vaughan or (Cambridge or (Halifax or Hamilton or London or Victoria or Waterloo or Welland or Whitby or Windsor)) or Whitehorse or Winnipeg or Wood Buffalo or Yellowknife).ti,ab.) not (UK or Britain or United Kingdom or Scotland or US or United States or USA or India or New Zealand or England or Australia).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]	
5	geriatrics/ or exp "aged (attitudes toward)"/ or exp aging/ or geriatric assessment/ or geriatricpsychotherapy/ or gerontology/ or exp geropsychology/ or late life depression/ or exp eldercare/ or elder abuse/ or (elders or elderly or geriatric* or old age or oldest age* or (seniors not "high school") or old* adult* or oldest patient* or "old old" or "very old" or centenarian* ornonagenarian* or octogenarian* or septuagenarian* or sexagenarian* or dottering or decrepitor tottering or late life or overaged or "oldest old").ti,ab,jn,jx,mh,sh.	177964
6	adolescent development/ or childhood development/ or pediatrics/ or exp Congenital Disorders/ or child characteristics/ or child abuse/ or exp child welfare/ or chronically ill children/ or child neglect/ or child psychiatry/ or child psychopathology/ or exp child care/ or (pediatric* or paediatric* or child* or newborn* or congenital* or infan* or baby or babies or neonat* or pre term or preterm* or premature birth or NICU or preschool* or pre school* or kindergarten* or elementary school* or nursery school* or schoolchild* or toddler* or boy or boys or girl* or middle school* or pubescen* or juvenile* or teen* or youth* or high school* or adolesc* or prepubesc* or pre pubesc*).mp. or (child* or adolesc* or pediat* or paediat*).jn.	1286873
7	(fetus* or fetal or foetus* or foetal* or "in utero").mp.	17238
8	exp Refugees/ or Immigration/ or (immigrant* or immigration or emigrant* or emigration or refugee* or asylum seeker* or asylee* or displaced person* or "incomer*" or "in comer*" or "new comer*" or newcomer* or migrant* or resettler*).mp.	50895

| 9 | exp American Indians/ or indigenous populations/ or exp Inuit/ or exp Health Services, Indigenous/ or exp Ethnopharmacology/ or Athapaskan.mp. or Saulteaux.mp. or Wakashan.mp. or Cree.mp. or Dene.mp. or Inuit.mp. or Inuk.mp. or Inuvialuit*.mp. or Haida.mp. or Ktunaxa.mp. or Tsimshian.mp. or Gitsxan.mp. or Nisga'a.mp. or Haisla.mp. or Heiltsuk.mp. or Oweenkeno.mp. or Kwakwaka'wakw.mp. or Nuu chah nulth.mp. or Tsilhqot'in.mp. or Dakelh.mp. or Wet'suwet'en.mp. or Sekani.mp. or Dunne-za.mp. or Dene.mp. or Tahltan.mp. or Kaska.mp. or Tagish.mp. or Tutchone.mp. or Nuxalk.mp. or Salish.mp. or Stl'atlimc.mp. or Nlaka'pamux.mp. or Okanagan.mp. or Sec wepmc.mp. or Tlingit.mp. or Anishinaabe.mp. or Blackfoot.mp. or Nakoda.mp. or Tasttine.mp. or Tsuu T'inia.mp. or Gwich'in.mp. or Han.mp. or Tagish.mp. or Tutchone.mp. or Algonquin.mp. or Nipissing.mp. or Ojibwa.mp. or Potawatomi.mp. or Innu.mp. or Maliseet.mp. or Mi'kmaq.mp. or Micmac.mp. or Passamaquoddy.mp. or Haudenosaunee.mp. or Cayuga.mp. or Mohawk.mp. or Oneida.mp. or Onodaga.mp. or Seneca.mp. or Tuscarora.mp. or Wyandot.mp. or Aboriginal*.mp. or Indigenous*.mp. or Metis.mp. or red road.mp. or "on reserve".mp. or off-reserve.mp. or First Nation.mp. or First Nations.mp. or Amerindian.mp. or (urban adj3 (Indian* or Native* or Aboriginal*)).mp. or ethnomedicine.mp. or country food*.mp. or residential school*.mp. or ((exp Medicine, Traditional/ or traditional medicine*.mp.) not Chinese.mp.) or exp Shamanism/ or shaman*.mp. or traditional heal*.mp. or traditional food*.mp. or medicine man.mp. or medicine woman.mp. or autochtone*.mp. or (Native* adj1 (man or men or women or woman or boy* or girl* or adolescent* or youth or youths or person* or adult or people* or Indian* or Nation or tribe* or tribal or band or bands)).mp. | 31529 |
| 10 | occupational exposure/ or ((agricultur* or forest* or farm* or field or fields) adj3 (work* or labo?*)).mp. or (arborist* or archaeologist* or (fruit adj3 picker*) or farm labo?r or berry pick* or cowboy* or cowgirl* or "deck hand" or dog walker* or farmworker* or fisher* worker* or fisherm?n or firefighter* or fire fighter* or farmer* or farmhand* or forester or flagm?n or flagwom?n or greens keeper* or grounds keeper* or gardener* or garbagewom* or (garbage adj3 (man or men or women or woman or collector* or worker*)) or herder* or hunter* or letter carrier* or lifeguard* or landscaper* or mail carrier* or marine biologist* or mariner* or ((outdoor* or outside or "out of doors") adj3 (work* or employment or construction* or job or jobs)) or playground supervisor* or power line technician* or ski instructor* or ski patrol* or ranger or rangers or "rig hand*" or sailor* or parks worker* or shepherd* or smoke jumper* or stoop labo?r* or trapper* or tree planter* or (vegetable adj3 picker*) or wildlife biologist*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh] | 27208 |

11	exp homeless/ or shelters/ or (((vulnerable or migrant or transient*) adj2 (people or person* or individual* or child* or youth* or population* or worker* or men or women or man or woman)) or (street adj2 (people or person* or individual* or youth* or population* or child* or men or women or man or woman)) or ("hard to houseor lack of housing" or "substandard housing" or "unstably housed" or underhoused or "under housed" or squatter* or homeless* or vagabond* or vagrant* or indigent) or (marginal* adj2 (population* or people* or group* or hous*))).mp.	30389
12	5 or 6 or 7 or 8 or 9 or 10 or At Risk Populations/	1528886
13	2 and 4 and 12	189
14	(smoker* or smoking or "who smoke" or squirrel*).mp. [mp=title, abstract, heading word, table of contents, key concepts, original title, tests & measures, mesh]	61725
15	13 not 14	53
16	remove duplicates from 15	53
17	limit 16 to yr="2010 - 2021"	31
18	from 17 keep 1-31	31

EBSCO CINAHL Searched June 7, 2020

#	Query	Limiters Expanders	Results
S1	(health* or disease* or outbreak* or infectio* or illness* or virus* or injur* or disorder* or epidemic* or pandemic* or fever* or symptoms or (deformit* or malformation* or cleft-palate* or cleft-lip* or	Expanders - Apply equivalent subjects	4,075,162

		Search modes - Find all my search terms	
	birth-defect* or congenital heart defect* or spina-bifida or birth-outcome* or pregnancy-outcome* or still-birth or still-born* or stillborn or stillbirth* or low-birth-weight or (fetal-growth Near (restric* or retard*)) or preterm labo* or preterm birth or (hypertension and pregnan*) or preeclampsia) or (((developmental* or intellectual* or learning or mental or cognitive or physical*) Near/3 (disab* or impair* or delay* or disorder*)) or mental retard* or handicap* or special needs or down* syndrome or "fragile x" or autis* or asperger* or pervasive developmental disorder* or cerebral palsy or tourette* or tic-disorder* or attention-deficit* or adhd or epilep* or language-disorder* or neurodevelopment* or ((neuro or cognitive or physical*) Near/5 development*)) Near/ 6 water) or (mortalit* or death* or fatalit*) or (respiratory or asthma* or allerg* or aeroallerg* or ((breathing or breathe) Near/3 (issue* or problem* or difficult* or struggl* or trouble))) or (heat-stress* or heat-exhaustion or heat-stroke* or heatstroke* or sun stroke* or sunstroke*) or (cholera* or diarrhea* or diarrhoea* or dysentery or salmonella or pneumonia* or plasmodium* or babesi* or hantavirus* or giardia* or cryptosporidi* or leptospiros*) or (Trichinos* or trichinellosis or Chikungunya or Dengue or Lymphatic-filariasis or Rift-Valley-fever or Yellow-fever or Zika or Malaria or japanese-encephalitis or tick-borne or West-Nile-fever or Leishmaniasis or Sandfly-fever or phelebotomus-fever or haemorrhagic-fever or Lyme-disease or Relapsing-fever or borreliosis or Rickettsial-diseases or spotted-fever or Q-fever or Tularaemia or Chagas or trypanosomiasis or Sleeping-sickness or Plague or Rickettsiosis or Onchocerciasis or river-blindness or Schistosomiasis or bilharziasis or Typhus or louse-borne-relapsing-fever)	Search modes - Find all my search terms	
S2	ti ((ambient OR season* OR seasonal* OR climate OR climatic OR weather OR summer OR winter OR (((climat* AND NOT (political-climate OR "organizational climate*" OR economic-climate OR financial-climate)) OR weather) N/3 (chang* OR disrupt* OR volati* OR instabilit* OR unstable OR variable OR variability OR vulnerab*)) OR ((chang* OR decline* OR decrease* OR increase*) N/3 humidity) OR ((global* OR climate) N/2 warm*) OR ((climat* OR weather) N/1 (conditions OR factors OR driven)) OR ("greenhouse gas*" OR "greenhouse effect*" OR "carbon emission*" OR "carbon dioxide emission*" OR "CO2 emission*"))) OR (((extreme OR severe) N/1 (weather OR heat OR hot* OR temperature*)) OR ((annual* OR daily OR month* OR ambient OR environmental OR season* OR climate OR climatic OR weather OR summer OR winter) N/4 temperature*) OR (warm-season* OR warm*-month* OR ((unseasonabl* OR unusual*) N/3 (warm OR hot OR heat OR humid* OR cold OR high OR low)))) OR ((("El Nino" OR "La Nina") OR (rain OR rains OR rainstorm* OR raining OR rainfall OR ((high OR heavy OR extreme OR severe OR daily OR levels) N/2 precipitation) OR uv-index OR flooding OR floods OR waterlogging OR (drought* AND NOT drought-resistan*) OR desertifcation OR hurricane* OR cyclone* OR tornado* OR superstorm* OR "dust storm*" OR "storm surge*" OR "ice storm*" OR ((storm OR storms) AND disaster*) OR monsoon*) OR ("forest fire*" OR wildfire* OR "wild fire*" OR "fire disaster*" OR (uncontrolled N/2 fire*)) OR (("sea level*" N/3 (rise OR rises OR rising OR increase OR increasing OR increases)) OR ((polar OR permafrost OR ice-cap OR glacier*) N/3 (melt* OR retreat* OR reced* OR thaw*))) OR famine*))	Search modes - Find all my search terms	30,332

S3	ti (((carbon monoxide* or hydrogen sulfide* or hydrogen sulphide* or H2S or nitrogen oxide* or volatile organic* or voc or nox or sulfur dioxide* or sulfur oxide* or sulphur dioxide* or sulphur oxide*) and (pollut* or emit* or emission* or contaminat* or decontaminat*)) or ((air or atmospher*) N/3 (pollut* or quality or wast* or contamin* or emission* or immission* or effluent*or acidification or contaminat* or degrad* or decontaminat* or purif* or restor*)) or ((gas or gases) N/3 (toxic* or noxious or releas* or purifi* or scrub* or emit* or waste* or vapo?r)) or (acid* N/3 (deposition* or rain* or snow or fog or mist or precipitation or hail or sleet)) or afterburning or biogas or (burning adj3 fossil fuel*) or ((chimney or stack) N/3 height) or dust or fallout or fall out or flaring or fly ash or electrosmog or (greenhouse N/3 (gas or effect or effects or gases or emission*)) or incineration or odor or odour or olfactory pollution or particulate* or smog or smoke or soot or sick building syndrome or vapo?r recovery system* or ((industrial or automobile* or traffic or freeway or highway or roadway or motorway or diesel or vehicle*) N/3 (exhaust* or emission* or emit* or fume or fumes or vapo?r*)))	Search modes - Find all my search terms	10,316
S4	(pediatric* or paediatric* or child* or newborn* or congenital* or infan* or baby or babies or neonat* or "pre-term" or preterm or "premature birth*" or NICU or preschool* or "pre-school*" or kindergarten* or "elementary school*" or "nursery school*" or schoolchild* or toddler* or boy or boys or girl* or "middle school*" or pubescen* or juvenile* or teen* or youth* or "high school*" or adolesc*or prepubesc* or "pre-pubesc*" or "(MH "Child+") OR (MH "Adolescence+") OR (MH "Minors (Legal)") or "(MH "Child Abuse, Sexual") OR (MH "Child Behavior Disorders+") OR (MH "Child, Medically Fragile") OR (MH "Child Day Care") OR (MH "Child Behavior+") OR (MH "Child Mortality") OR (MH "Child Passenger Safety") OR (MH "Child Development Disorders, Pervasive+") OR (MH "Child Custody") OR (MH "Child Abuse+") OR (MH "Child Nutritional Physiology+") OR (MH "Child Behavior Checklist")) OR SO (child* or pediatric* or paediatric* or adolescent)	Expanders - Apply equivalent subjects Search modes - Find all my search terms	1,211,998
S5	Saulteaux or Wakashan or Cree or Dene or Inuit or Inuk or Inuvialuit* or Haida or Ktunaxa or Tsimshian or Gitsxan or Nisga'a or Haisla or Heiltsuk or Oweenkeno or Kwakwaka'wakw or Nuu chah nulth or Tsilhqot'i. or Dakelh or Wet'suwet'en or Sekani or Dunne-za or Dene or Tahltan or Kaska or Tagish or Tutchone or Nuxalk or Salish or Stl'atlimc or Nlaka'pamux or Okanagan or Sec wepmc or Tlingit or Anishinaabe or Blackfoot or Nakoda or Tasttine or Tsuu T'inia or Gwich'in or Han or Tagish or Tutchone or Algonquin or Nipissing or Ojibwa or Potawatomi or Innu or Maliseet or Mi'kmaq or Micmac or Passamaquoddy or Haudenosaunee or Cayuga or Mohawk or Oneida or Onodaga or Seneca or Tuscarora or Wyandot or Aboriginal* or Indigenous* or Metis or red road or "on reserve" or off-reserve or First Nation or First Nations or Amerindian or "urban indian*" or "urban native*" or "country food*" or "residential school*" or shaman* or "traditional heal*" or "traditional food*" or "medicine man" or "medicine woman" or autochtone*	Expanders - Apply equivalent subjects Search modes - Find all my search terms	41,947
S6	arborist* or archaeologist* or "fruit picker*" or "farm labor*" or "farm labour*" or berry pick* or cowboy* or cowgirl* or "deck hand" or dog walker* or farmworker* or fisher* worker* or fisherm?n or firefighter* or fire fighter* or farmer* or farmhand* or forester or flagm* or flagwom* or "greens keeper*" or "grounds keeper*" or gardener* or garbagewom* or "garbage man"or "garbage men" or	Expanders - Apply equivalent subjects Search modes - Boolean/Phrase	19,710

	"garbage women"or "garbage woman" or garbage collector* or garbage worker* or herder* or hunter* or "letter carrier*" or lifeguard* or landscaper* or "mail carrier*" or "marine biologist*" or mariner* or "outdoor* work*" or "outdoor employment*" or "outdoor construction" or "outdoor job* or "outside work*" or "outside employment*" or "outside construction*" or "outside job*" or "out of doors work*" or "out of doors employment" or "out of doors job*" or "playground supervisor*"		
S7	"power line technician*" or "ski instructor*" or "ski patrol*" or ranger or rangers or "rig hand*" or sailor* or "parks worker*" or shepherd* or "smoke jumper*" or "stoop labour*" OR "stoop labour*" or trapper* or "tree planter*" or "vegetable picker*" or "wildlife biologist*"	Expanders - Apply equivalent subjects Search modes - Find all my search terms	1,119
S8	MH ("Homeless People") or MH ("Homelessness") or ((vulnerable or migrant or transient*) N2 (people or person* or individual* or child* or youth* or population* or worker* or men or women or man or woman)).mp. or (street N2 (people or person* or individual* or youth* or population* or child* or men or women or man or woman)).mp. or (hard to house or lack of housing or substandard housing or unstably housed or underhoused or under housed or squatter* or homeless* or vagabond* or vagrant* or indigent).mp. or (marginal* N2 (population* or people* or group* or hous*))	Expanders - Apply equivalent subjects Search modes - Find all my search terms	6,666
S9	S4 or S5 OR S6 OR S7	Expanders - Apply equivalent subjects Search modes - Find all my search terms	1,263,287
S10	AB (((carbon monoxide* or hydrogen sulfide* or hydrogen sulphide* or H2S or nitrogen oxide* or volatile organic* or voc or nox or sulfur dioxide* or sulfur oxide* or sulphur dioxide* or sulphur oxide*) and (pollut* or emit* or emission* or contaminat* or decontaminat*)) or ((air or atmospher*) N/3 (pollut* or quality or wast* or contamin* or emission* or immission* or effluent*or acidification or contaminat* or degrad* or decontaminat* or purif* or restor*)) or ((gas or gases) N/3 (toxic* or noxious or releas* or purifi* or scrub* or emit* or waste* or vapo?r)) or (acid* N/3 (deposition* or rain* or snow or fog or mist or precipitation or hail or sleet)) or afterburning or biogas or (burning adj3 fossil fuel*) or ((chimney or stack) N/3 height) or dust or fallout or fall out or flaring or fly ash or electrosmog or (greenhouse N/3 (gas or effect or effects or gases or emission*)) or incineration or odor or odour or olfactory pollution or particulate* or smog or smoke or soot or sick building syndrome or vapo?r recovery system* or ((industrial or automobile* or traffic or freeway or highway or roadway or motorway or diesel or vehicle*) N/3 (exhaust* or emission* or emit* or fume or fumes or vapo?r*)))	Expanders - Apply equivalent subjects Search modes - Find all my search terms	25,858
S11	AB ((ambient OR season* OR seasonal* OR climate OR climatic OR weather OR summer OR winter OR (((climat* AND NOT (political-climate OR "organizational climate*" OR economic-climate OR financial-climate)) OR weather) N/3 (chang* OR disrupt* OR volati* OR instabilit* OR unstable OR variable OR variability OR vulnerab*)) OR ((chang* OR decline* OR decrease* OR increase*) N/3	Expanders - Apply equivalent subjects Search modes - Find all my search terms	48,844

	humidity) OR ((global* OR climate) N/2 warm*) OR ((climat* OR weather) N/1 (conditions OR factors OR driven)) OR ("greenhouse gas*" OR "greenhouse effect*" OR "carbon emission*" OR "carbon dioxide emission*" OR "CO2 emission*"))) OR (((extreme OR severe) N/1 (weather OR heat OR hot* OR temperature*)) OR ((annual* OR daily OR month* OR ambient OR environmental OR season* OR climate OR climatic OR weather OR summer OR winter) N/4 temperature*) OR (warm-season* OR warm*-month* OR ((unseasonabl* OR unusual*) N/3 (warm OR hot OR heat OR humid* OR cold OR high OR low)))) OR ((("El Nino" OR "La Nina") OR (rain OR rains OR rainstorm* OR raining OR rainfall OR ((high OR heavy OR extreme OR severe OR daily OR levels) N/2 precipitation) OR uv-index OR flooding OR floods OR waterlogging OR (drought* AND NOT drought-resistan*) OR desertifcation OR hurricane* OR cyclone* OR tornado* OR superstorm* OR "dust storm*" OR "storm surge*" OR "ice storm*" OR ((storm OR storms) AND disaster*) OR monsoon*) OR ("forest fire*" OR wildfire* OR "wild fire*" OR "fire disaster*" OR (uncontrolled N/2 fire*)) OR (("sea level*" N/3 (rise OR rises OR rising OR increase OR increasing OR increases)) OR ((polar OR permafrost OR ice-cap OR glacier*) N/3 (melt* OR retreat* OR reced* OR thaw*))) OR famine*))		
S12	S2 OR S3 OR S10 OR S11	Expanders - Apply equivalent subjects Search modes - Find all my search terms	99,434
S13	TI ((((Cambridge or (Halifax or Hamilton or London or Victoria or Waterloo or Welland or Whitby or Windsor)) not (UK or Britain or United Kingdom or England or Australia)))) OR AB ((((Cambridge or (Halifax or Hamilton or London or Victoria or Waterloo or Welland or Whitby or Windsor)) not (UK or Britain or United Kingdom or England or Australia))))	Expanders - Apply equivalent subjects Search modes - Find all my search terms	21,705
S14	TI (canad* or "british columbia" or alberta* or saskatchewan or manitoba* or ontario or quebec or (new brunswick not new jersey) or nouveau brunswick or nova scotia or nouvelle ecosse or prince edward island or newfoundland or labrador or nunavut or nwt or northwest territories or yukon or nunavik or inuvialuit or Abbotsford or Airdrie or Ajax or Aurora or Barrie or Belleville or Blainville or Brampton or Brantford or Brossard or Burlington or Burnaby or Caledon or Calgary or Cape Breton or Chatham Kent or Chilliwack or Clarington or Coquitlam or Drummondville or Edmonton or Fredericton or Fort McMurray or Gatineau or Granby or Grande Prairie or Sudbury or Guelph or Halton Hills or Iqaluit or Inuvik or Kamloops or Kawartha Lakes or Kelowna or Kingston or Kitchener or Langley or Laval or Lethbridge or Levis or Longueuil or Maple Ridge or Markham or Medicine Hat or Milton or Mirabel or Mississauga or Moncton or Montreal or Nanaimo or New Westminster or Newmarket or Niagara Falls or Norfolk County or North Bay or North Vancouver or North Vancouver or Oakville or Oshawa or Ottawa or Peterborough or Pickering or Port Coquitlam or Prince George or Quebec City or Red Deer or Regina or Repentigny or Richmond or Richmond Hill or Saanich or Saguenay or Saint John or Saint-Hyacinthe or Saint-Jean-sur-Richelieu or Saint-Jerome or Sarnia or Saskatoon or Sault Ste Marie or Sherbrooke or St Albert or St Catharines or St John's or Strathcona County or Surrey or Terrebonne or Thunder Bay or Toronto or Trois-Rivieres or Vancouver or Vaughan or Whitehorse or	Expanders - Apply equivalent subjects Search modes - Find all my search terms	98,542

	Winnipeg or Wood Buffalo or Yellowknife) OR AB (canad* or "british columbia" or alberta* or saskatchewan or manitoba* or ontario or quebec or (new brunswick not new jersey) or nouveau brunswick or nova scotia or nouvelle ecosse or prince edward island or newfoundland or labrador or nunavut or nwt or northwest territories or yukon or nunavik or inuvialuit or Abbotsford or Airdrie or Ajax or Aurora or Barrie or Belleville or Blainville or Brampton or Brantford or Brossard or Burlington or Burnaby or Caledon or Calgary or Cape Breton or Chatham Kent or Chilliwack or Clarington or Coquitlam or Drummondville or Edmonton or Fredericton or Fort McMurray or Gatineau or Granby or Grande Prairie or Sudbury or Guelph or Halton Hills or Iqaluit or Inuvik or Kamloops or Kawartha Lakes or Kelowna or Kingston or Kitchener or Langley or Laval or Lethbridge or Levis or Longueuil or Maple Ridge or Markham or Medicine Hat or Milton or Mirabel or Mississauga or Moncton or Montreal or Nanaimo or New Westminster or Newmarket or Niagara Falls or Norfolk County or North Bay or North Vancouver or North Vancouver or Oakville or Oshawa or Ottawa or Peterborough or Pickering or Port Coquitlam or Prince George or Quebec City or Red Deer or Regina or Repentigny or Richmond or Richmond Hill or Saanich or Saguenay or Saint John or Saint-Hyacinthe or Saint-Jean-sur-Richelieu or Saint-Jerome or Sarnia or Saskatoon or Sault Ste Marie or Sherbrooke or St Albert or St Catharines or St John's or Strathcona County or Surrey or Terrebonne or Thunder Bay or Toronto or Trois-Rivieres or Vancouver or Vaughan or Whitehorse or Winnipeg or Wood Buffalo or Yellowknife)		
S15	(MH "Canada+")	Expanders - Apply equivalent subjects Search modes - Find all my search terms	109,684
S16	S13 OR S14 OR S15	Expanders - Apply equivalent subjects Search modes - Find all my search terms	172,418
S17	S1 AND S9 AND S12 AND S16	Expanders - Apply equivalent subjects Search modes - Find all my search terms	963
S18	S1 AND S9 AND S12 AND S16	Limiters - Published Date: 20100101-20201231 Expanders - Apply equivalent subjects Search modes - Find all my search terms	650

SCOPUS Searched June 7. 2020

(((((TITLE-ABS-KEY (afterburning OR smog OR electrosmog OR flaring OR ordor OR odour OR fly-ash OR flyash OR "fall out" OR "acid rain" OR "acid precipitation" OR "airborne particulate")) OR (TITLE-ABS-KEY ((air OR atmosphere OR gas*) W/3 (emission* OR immission* OR quality OR pollut* OR vapor* OR vapour* OR purifi* OR fume*))) OR (TITLE-ABS-KEY (dust OR ((industrial OR traffic OR automobile OR diesel OR vehicle OR roadway OR motorway OR highway) AND (emit* OR emiss* OR vapor* OR vapour* OR fume*)))) OR (TITLE-ABS-KEY ("workplace air" OR "factory air" OR "airborne pesticide*" OR "airborne herbicide*" OR "airborne insecticide*" OR "insecticide mist*" OR "pesticide mist*" OR "herbicide mist*")) OR (TITLE-ABS-KEY ("climat* change" OR global-climate* OR "climate event" OR "disaster storm*" OR "global warming" OR "evironmental change" OR "greenhouse gas*" OR "greenhouse effect*" OR "carbon emission*" OR "carbon dioxide emission*" OR "CO2 emission*" OR desertifcation OR hurricane* OR cyclone* OR tornado* OR superstorm* OR "dust storm*" OR "storm surge*" OR "ice storm*" OR monsoon* OR "extreme heat" OR "extreme temperature*" OR "extreme cold" OR wildfire* OR "fire disaster*" OR "uncontrolled fire*" OR "sea level rise" OR "permafrost melt" OR "sea level ris*" OR "glacial retreat" OR "ice cap melt*" OR "thermohaline conveyor" OR "extreme precipitation" OR waterlogging OR flood* OR "El Nino" OR "La Nina" OR uv-index OR uv-rays OR "ozone hole"))))) AND (((TITLE-ABS-KEY ((elders OR elderly OR geriatric* OR "old age" OR "senior citizens" OR "older adult*" OR centenarian* OR nonagenarian* OR octogenarian* OR septuagenarian* OR sexagenarian* OR dottering OR decrepit OR tottering OR overaged OR "oldest old" OR pediatric* OR paediatric* OR child* OR newborn* OR congenital* OR infan* OR baby OR babies OR neonat* OR pre-term OR preterm* OR "premature birth*" OR nicu OR preschool* OR pre-school* OR kindergarten* OR kindergarden* OR "elementary school*" OR "nursery school*" OR "day care*" OR schoolchild* OR toddler* OR boy OR boys OR girl* OR "middle school*" OR pubescen* OR juvenile* OR teen* OR youth* OR "high school*" OR adolesc* OR pre-pubesc* OR prepubesc* OR immigrant* OR immigration OR emmigrant* OR emmigration OR refugee* OR "asylum seeker*" OR asylee* OR "displaced person*" OR "incomer*" OR "in comer*" OR "new comer*" OR newcomer* OR childbearing OR childbirth OR pregnan* OR fertile OR fecund OR womanish OR womanly OR maternal OR vulnerable)))) OR (fetus* OR fetal OR foetus* OR foetal* OR "in utero") OR (TITLE-ABS-KEY (athapaskan OR saulteaux OR wakashan OR cree OR dene OR inuit OR inuk OR inuvialuit* OR haida OR ktunaxa OR tsimshian OR gitsxan OR "Nisga'a" OR haisla OR heiltsuk OR oweenkeno OR "Kwakwaka'wakw" OR "Nuu chah nulth" OR "Tsilhqot'in" OR dakelh OR "Wet'suwet'en" OR sekani OR dunne-za OR dene OR tahltan OR kaska OR tagish OR tutchone OR nuxalk OR salish OR "Stl'atlimc" OR "Nlaka'pamux" OR okanagan OR "Sec wepmc" OR tlingit OR anishinaabe OR blackfoot OR nakoda OR tasttine OR "Tsuu T'inia" OR "Gwich'in" OR han OR tagish OR tutchone OR algonquin OR nipissing OR ojibwa OR potawatomi OR innu OR maliseet OR mi'kmaq OR micmac OR passamaquoddy OR haudenosaunee OR cayuga OR mohawk OR oneida OR onodaga OR seneca OR tuscarora OR wyandot OR aboriginal* OR indigenous* OR metis OR "red road" OR "on reserve" OR off-reserve OR "First Nation" OR "First Nations" OR amerindian OR (urban W/3 (indian* OR native* OR aboriginal*)) OR ethnomedicine OR "country food*" OR "residential school*") OR (("traditional medicine*") AND NOT chinese) OR shaman* OR "traditional heal*" OR "traditional food*" OR "medicine man" OR "medicine woman" OR autochtone* OR (native* W/1 (man OR men OR women OR woman OR boy* OR girl* OR adolescent* OR youth OR youths OR person* OR adult OR people* OR indian* OR nation OR tribe* OR tribal OR band OR bands))) OR (TITLE-ABS-KEY (pregnan* OR "new mother*" OR puerperium OR obstetric* OR "labor and delivery" OR "labour and

delivery" OR partus OR gravidida OR "peri natal*" OR perinatal OR postpartum OR "post-partum" OR antinatal* OR "anti natal")) OR (TITLE-ABS-KEY (((agricultur* OR forest* OR farm* OR field OR fields) W/3 (work* OR labor* OR labour*)) OR (arborist* OR archaeologist* OR (fruit W/3 picker*) OR "farm labor*" OR "farm labour*" OR "berry pick*" OR cowboy* OR cowgirl* OR "deck hand" OR "dog walker*" OR farmworker* OR "fisher* worker*" OR fisherm* OR firefighter* OR "fire fighter*" OR farmer* OR farmhand* OR forester OR flagm* OR flagwom* OR "greens keeper*" OR "grounds keeper*" OR grounds W/3 worker* OR gardener* OR garbagewom* OR (garbage W/3 (man OR men OR women OR woman OR collector* OR worker*)) OR herder* OR hunter* OR "letter carrier*" OR lifeguard* OR landscaper* OR "mail carrier*" OR "marine biologist*" OR mariner* OR ((outdoor* OR outside OR "out of doors") W/3 (work* OR employment OR construction* OR job OR jobs)) OR "playground supervisor*" OR "power line technician*" OR "ski instructor*" OR "ski patrol*" OR ranger OR rangers OR "rig hand*" OR sailor* OR "parks worker*" OR shepherd* OR "smoke jumper*" OR "stoop labor*" OR "stoop labour*" OR trapper* OR homeless* OR "hard to house*" OR "unstabl* house*" OR "Street people" OR "street person" OR transient* OR migrant* OR "skid row" OR "insufficient hous*" OR squatting OR squatter* OR "tree planter*" OR (vegetable W/3 picker*) OR "wildlife biologist*")))) AND ((TITLE-ABS-KEY ((canad* OR "british columbia" OR alberta* OR saskatchewan OR manitoba* OR ontario OR quebec OR "new brunswick" OR "nouveau brunswick" OR "nova scotia" OR "nouvelle ecosse" OR "prince edward island" OR newfoundland OR labrador OR nunavut OR nwt OR "northwest territories" OR yukon OR nunavik OR inuvialuit)))) AND (((TITLE-ABS-KEY (health* OR disease* OR outbreak* OR infectio* OR illness* OR virus* OR injur* OR disorder* OR epidemic* OR pandemic* OR fever* OR symptoms OR (deformit* OR malformation* OR cleft-palate* OR cleft-lip* OR birth-defect* OR "congenital heart defect*" OR spina-bifida OR birth-outcome* OR pregnancy-outcome* OR still-birth OR still-born* OR stillborn OR stillbirth* OR low-birth-weight OR (fetal-growth W/3 (restric* OR retard*)) OR "preterm labo*" OR "preterm birth*" OR (hypertension AND pregnan*) OR preeclampsia) OR (((developmental* OR intellectual* OR learning OR mental OR cognitive OR physical*) W/3 (disab* OR impair* OR delay* OR disorder*)) OR "mental retard*" OR handicap* OR "special needs" OR "down* syndrome" OR "fragile x" OR autis* OR asperger* OR "pervasive developmental disorder*" OR "cerebral palsy" OR tourette* OR tic-disorder* OR attention-deficit* OR adhd OR epilep* OR language-disorder* OR neurodevelopment* OR ((neuro OR cognitive OR physical*) W/5 development*)) W/ 6 water) OR (mortalit* OR death* OR fatalit*) OR (respiratory OR asthma* OR allerg* OR aeroallerg* OR ((breathing OR breathe) W/3 (issue* OR problem* OR difficult* OR struggl* OR trouble))) OR (heat-stress* OR heat-exhaustion OR heat-stroke* OR heatstroke* OR "sun stroke*" OR sunstroke*) OR (cholera* OR diarrhea* OR diarrhoea* OR dysentery OR salmonella OR pneumonia* OR plasmodium* OR babesi* OR hantavirus* OR giardia* OR cryptosporidi* OR leptospiros*) OR (trichinos* OR trichinellosis OR chikungunya OR dengue OR lymphatic-filariasis OR rift-valley-fever OR yellow-fever OR zika OR malaria OR japanese-encephali))))) AND NOT (TITLE-ABS-KEY (mustelid* OR salmon* OR dog OR dogs OR squirrel* OR smoker* OR smoking OR animal* OR tarantula* OR fish* OR spruce* OR moss OR tree OR trees OR cottonwood* OR deer OR moose OR boar OR boars OR aphid* OR bryozoa* OR bird* OR rat OR rats OR mice OR mouse OR rabbit* OR cat OR cats)) AND (LIMIT-TO (PUBYEAR , 2020) OR LIMIT-TO (PUBYEAR , 2019) OR LIMIT-TO (PUBYEAR , 2018) OR LIMIT-TO (PUBYEAR , 2017) OR LIMIT-TO (PUBYEAR , 2016)

OR LIMIT-TO (PUBYEAR , 2015) OR LIMIT-TO (PUBYEAR , 2014) OR LIMIT-TO (PUBYEAR , 2013) OR LIMIT-TO (PUBYEAR , 2012) OR LIMIT-TO (PUBYEAR , 2011) OR LIMIT-TO (PUBYEAR , 2010))

Cochrane Libray Searched June 7, 2020

Search   Hits

#1   (elders OR elderly OR geriatric* OR "old age" OR "senior citizens" OR "older adult*" OR centenarian* OR nonagenarian* OR octogenarian* OR septuagenarian* OR sexagenarian* OR dottering OR decrepit OR tottering OR overaged OR "oldest old" OR pediatric* OR paediatric* OR child* OR newborn* OR congenital* OR infan* OR baby OR babies OR neonat* OR pre-term OR preterm* OR "premature birth*" OR nicu OR preschool* OR pre-school* OR kindergarten* OR kindergarden* OR "elementary school" OR "nursery school*" OR "day care*" OR schoolchild* OR toddler* OR boy O R boys OR girl* OR "middle school*" OR pubescen* OR juvenile* OR teen* OR youth* OR "high school*" OR adolesc* OR pre-pubesc* OR prepubesc* OR immigrant* OR immigration OR emmigrant* OR emmigration OR refugee* OR "asylum seeker*" OR asylee* OR "displaced person*" OR "incomer*" OR "in comer*" OR "new comer*" OR newcomer* OR childbearing OR childbirth OR pregnan* OR fertile OR fecund OR womanish OR womanly OR maternal OR vulnerable):ti,ab,kw (Word variations have been searched)   397577

#2   (Saulteaux or Wakashan or Cree or Dene or Inuit or Inuk or Inuvialuit* or Haida or Ktunaxa or Tsimshian or Gitsxan or Nisga'a or Haisla or Heiltsuk or Oweenkeno or Kwakwaka'wakw or Nuu chah nulth or Tsilhqot'i. or Dakelh or Wet'suwet'en or Sekani or Dunne-za or Dene or Tahltan or Kaska or Tagish or Tutchone or Nuxalk or Salish or Stl'atlimc or Nlaka'pamux or Okanagan or Sec wepmc or Tlingit or Anishinaabe or Blackfoot or Nakoda or Tasttine or Tsuu T'inia or Gwich'in or Han or Tagish or Tutchone or Algonquin or Nipissing or Ojibwa or Potawatomi or Innu or Maliseet or Mi'kmaq or Micmac or Passamaquoddy or Haudenosaunee or Cayuga or Mohawk or Oneida or Onodaga or Seneca or Tuscarora or Wyandot or Aboriginal* or Indigenous* or Metis or red road or "on reserve" or off-reserve or First Nation or First Nations or Amerindian or (urban adj3 (Indian* or Native* or Aboriginal*)) or ethnomedicin. or country food* or residential school* or shaman* or traditional heal* or traditional food* or medicine man or medicine woman or autochtone*):ti,ab,kw   24194

#3   MeSH descriptor: [Indians, North American] explode all trees   242

#4   MeSH descriptor: [Inuits] explode all trees   33

#5   (arborist* or archaeologist* or fruit picker* or farm labor* or farm labour* or berry pick* or cowboy* or cowgirl* or "deck hand" or dog walker* or farmworker* or fisher* worker* or fisherm?n or firefighter* or fire fighter* or farmer* or farmhand* or forester or flagm* or

flagwom* or greens keeper* or grounds keeper* or gardener* or garbagewom* or garbage man or garbage men or garbage women or garbage woman or garbage collector* or garbage worker* or herder* or hunter* or letter carrier* or lifeguard* or landscaper* or mail carrier* or marine biologist* or mariner* or outdoor* work* or outdoor employment* or outdoor construction* or outdoor job* or outside work* or outside employment* or outside construction* or outside job* or "out of doors work*" or "out of doors employment" or "out of doors job*" or playground supervisor* or power line technician* or ski instructor* or ski patrol* or ranger or rangers or "rig hand*" or sailor* or parks worker* or shepherd* or smoke jumper* or stoop labour* or stoop labour *or trapper* or tree planter* or vegetable picker* or wildlife biologist*):ti,ab,kw   2718

#6   #1 or #2 or #3 or #4 or #5   414043

#7   ("climat* change" or global-climate* OR "climate event" or

"disaster storm*" or "global warming" or "evironmental change" or

"greenhouse gas*" OR "greenhouse effect*" OR "carbon emission*"

OR "carbon dioxide emission*" OR "CO2 emission*" or desertifcation

OR hurricane* OR cyclone* OR tornado* OR superstorm* OR "dust storm*"

OR "storm surge*" OR "ice storm*" OR monsoon* or "extreme heat"

or "extreme temperature*" or "extreme cold" or wildfire* or "fire disaster*"

or "uncontrolled fire*" or "sea level rise" or "permafrost melt" or "sea level ris*"

or "glacial retreat" or "ice cap melt*" or "thermohaline conveyor" or "extreme

precipitation" or waterlogging or flood* or "El Nino" or "La Nina" or uv-index

or uv-rays or ozone hole):ti   124

#8   (((air or atmosphere or gas*) AND (emission* or immission* or quality or pollut* or vapor* or vapour* or purifi* or fume*))):ti   807

#9   ((afterburning or smog or electrosmog or flaring or ordor or odour or "fly ash" or "fall out" or "acid rain" or "acid precipitation" or ' "airborne particulate")):ti,ab,kw1530

#10   ((dust or ((industrial or traffic or automobile or diesel of vehicle   or roadway or motorway or highway) and (emit* or emiss* or vapor* or vapour* or fume*)))):ti   909

#11   (("workplace air" or "factory air" or "airborne pesticide*" or "airborne herbicide*" or "airborne insecticide*" or "insecticide mist*" or "pesticide mist*" or "herbicide mist*")):ti,ab,kw 6

#12   #7 or #8 or #9 or #10 or #11   3355

#13   (((Cambridge or (Halifax or Hamilton or London or Victoria or Waterloo or Welland or Whitby or Windsor)) not (UK or Britain or United Kingdom or England or Australia))):ti,ab,kw   11606

#14   canad* or "british columbia" or alberta* or saskatchewan or manitoba* or ontario or quebec or (new brunswick not new jersey) or nouveau brunswick or nova scotia or nouvelle ecosse or prince edward island or newfoundland or labrador or nunavut or nwt or northwest territories or yukon or nunavik or inuvialuit or Abbotsford or Airdrie or Ajax or Aurora or Barrie or Belleville or Blainville or Brampton or Brantford or Brossard or Burlington or Burnaby or Caledon or Calgary or Cape Breton or Chatham Kent or Chilliwack or Clarington or Coquitlam or Drummondville or Edmonton or Fredericton or Fort McMurray or Gatineau or Granby or Grande Prairie or Sudbury or Guelph or Halton Hills or Iqaluit or Inuvik or Kamloops or Kawartha Lakes or Kelowna or Kingston or Kitchener or Langley or Laval or Lethbridge or Levis or Longueuil or Maple Ridge or Markham or Medicine Hat or Milton or Mirabel or Mississauga or Moncton or Montreal or Nanaimo or New Westminster or Newmarket or Niagara Falls or Norfolk County or North Bay or North Vancouver or North Vancouver or Oakville or Oshawa or Ottawa or Peterborough or Pickering or Port Coquitlam or Prince George or Quebec City or Red Deer or Regina or Repentigny or Richmond or Richmond Hill or Saanich or Saguenay or Saint John or Saint-Hyacinthe or Saint-Jean-sur-Richelieu or Saint-Jerome or Sarnia or Saskatoon or Sault Ste Marie or Sherbrooke or St Albert or St Catharines or St John's or Strathcona County or Surrey or Terrebonne or Thunder Bay or Toronto or Trois-Rivieres or Vancouver or Vaughan or Whitehorse or Winnipeg or Wood Buffalo or Yellowknife:ti,ab   67940

#15   MeSH descriptor: [Canada] explode all trees   3429

#16   #13 or #14 or #15   78496

#17   #6 and #12 and #16   63

#18   #17 with Cochrane Library publication date Between Jan 2010 and Dec 2020   45

Proquest Dissertations and Theses Global Searched June 7, 2020 Results =140

(noft(((elders OR elderly OR geriatric* OR "old age" OR "senior citizens" OR "older adult*"

OR centenarian* OR nonagenarian* OR octogenarian* OR septuagenarian* OR sexagenarian* OR dottering OR decrepit OR tottering OR overaged OR "oldest old" OR pediatric* OR paediatric* OR child* OR newborn* OR congenital* OR infan* OR baby OR babies OR neonat* OR pre-term OR preterm* OR "premature irth*" OR nicu OR preschool* OR pre-school* OR kindergarten* OR

kindergarden* OR "elementary school*" OR "nursery school*" OR "day care*" OR schoolchild* OR toddler* OR boy OR boys OR girl* OR "middle school*" OR pubescen* OR juvenile* OR teen* OR youth* OR "high school*" OR adolesc* OR pre-pubesc* OR prepubesc* OR immigrant* OR immigration OR emmigrant* OR emmigration OR refugee* OR "asylum seeker*" OR asylee* OR "displaced person*" OR "incomer*" OR "in comer*" OR "new comer*" OR newcomer* OR childbearing OR childbirth OR pregnan* OR fertile OR fecund OR womanish OR womanly OR maternal OR vulnerable))) OR ((vulnerable or migrant or transient*) N2 (people or person* or individual* or child* or youth* or population* or worker* or men or women or man or woman)) or (street N2 (people or person* or individual* or youth* or population* or child* or men or women or man or woman)) or (hard to house or lack of housing or substandard housing or unstably housed or underhoused or under housed or squatter* or homeless* or vagabond* or vagrant* or indigent) or (marginal* N2 (population* or people* or group* or hous*)) OR noft(Saulteaux OR Wakashan OR Cree OR Dene OR Inuit OR Inuk OR Inuvialuit* OR Haida OR Ktunaxa OR Tsimshian OR Gitsxan OR Nisga'a OR Haisla OR Heiltsuk OR Oweenkeno OR Kwakwaka'wakw OR Nuu chah nulth OR Tsilhqot'i. OR Dakelh OR Wet'suwet'en OR Sekani OR Dunne-za OR Dene OR Tahltan OR Kaska OR Tagish OR Tutchone OR Nuxalk OR Salish OR Stl'atlimc OR Nlaka'pamux OR Okanagan OR Sec wepmc OR Tlingit OR Anishinaabe OR Blackfoot OR Nakoda OR Tasttine OR Tsuu T'inia OR Gwich'in OR Han OR Tagish OR Tutchone OR Algonquin OR Nipissing OR Ojibwa OR Potawatomi OR Innu OR Maliseet OR Mi'kmaq OR Micmac OR Passamaquoddy OR Haudenosaunee OR Cayuga OR Mohawk OR Oneida OR Onodaga OR Seneca OR Tuscarora OR Wyandot OR Aboriginal* OR Indigenous* OR Metis OR red road OR "on reserve" OR off-reserve OR First Nation OR First Nations OR Amerindian) OR noft("urban indian*" OR "urban native*" OR "country food*" OR "residential school*" OR shaman* OR "traditional heal*" OR "traditional food*" OR "medicine man" OR "medicine woman" OR autochtone*) OR noft(#4 arborist* OR archaeologist* OR fruit picker* OR farm labor* OR farm labour* OR berry pick* OR cowboy* OR cowgirl* OR "deck hand" OR dog walker* OR farmworker* OR fisher* worker* OR fisherm?n orghter* OR fire fighter* OR farmer* OR farmhand* OR forester OR flagm* OR flagwom* OR " greens firefikeeper*" OR "grounds keeper*" OR gardener* OR garbagewom* OR garbage man OR garbage men OR garbage women OR garbage woman OR garbage collecton* OR garbage worker* OR herder* OR hunter* OR letter carrier* OR lifeguard* OR landscaper* OR mail carrier* OR marine biologist* OR mariner* OR outdoor* work* OR "outdoor employment*" OR "outdoor construction*") OR noft("outdoor job*" OR "outside work*" OR "outside employment*" OR "outside construction*" OR "outside job*" OR "out of doors work*" OR "out of doors employment" OR "out of doors job*" OR "playground supervisor*") OR noft("power line technician*" OR "ski instructor*" OR "ski patrol*" OR ranger OR rangers OR "rig hand*" OR sailor* OR "parks worker*" OR shepherd* OR "smoke jumper*" OR "stoop labour*") OR noft("stoop labour*" OR trapper* OR "tree planter*" OR "vegetable picker*" OR "wildlife biologist*")) AND (ab((((Cambridge OR (Halifax OR Hamilton OR London OR Victoria OR Waterloo OR Welland OR Whitby OR Windsor)) NOT (UK OR Britain OR United Kingdom OR England OR Australia)))) OR ti((((Cambridge OR (Halifax OR Hamilton OR London OR Victoria OR Waterloo OR Welland OR Whitby OR Windsor)) NOT (UK OR Britain OR United Kingdom OR England OR Australia)))) OR ti(canad* OR "british columbia" OR alberta* OR saskatchewan OR manitoba* OR ontario OR quebec OR (new brunswick NOT new jersey) OR nouveau brunswick OR nova scotia OR nouvelle ecosse OR prince edward island OR newfoundland OR labrador OR nunavut OR nwt OR northwest territories OR yukon OR nunavik OR inuvialuit OR Abbotsford OR Airdrie OR Ajax OR Aurora OR Barrie OR Belleville OR Blainville OR Brampton OR Brantford OR Brossard OR Burlington OR Burnaby OR Caledon OR Calgary OR Cape Breton OR Chatham Kent OR Chilliwack OR Clarington OR Coquitlam OR Drummondville OR Edmonton OR Fredericton OR Fort McMurray OR Gatineau OR Granby OR Grande Prairie OR Sudbury OR Guelph OR Halton Hills OR Iqaluit OR Inuvik OR Kamloops OR Kawartha Lakes OR Kelowna OR Kingston OR Kitchener OR Langley OR Laval OR Lethbridge OR Levis OR Longueuil OR Maple Ridge OR Markham OR Medicine Hat OR Milton OR Mirabel OR Mississauga OR Moncton OR Montreal OR Nanaimo OR

New Westminster OR Newmarket OR Niagara Falls OR Norfolk County OR North Bay OR North Vancouver OR North Vancouver OR Oakville OR Oshawa OR Ottawa OR Peterborough OR Pickering OR Port Coquitlam OR Prince George OR Quebec City OR Red Deer OR Regina OR Repentigny OR Richmond OR Richmond Hill OR Saanich OR Saguenay OR Saint John OR Saint-Hyacinthe OR Saint-Jean-sur-Richelieu OR Saint-Jerome OR Sarnia OR Saskatoon OR Sault Ste Marie OR Sherbrooke OR St Albert OR St Catharines OR St John's OR Strathcona County OR Surrey OR Terrebonne OR Thunder Bay OR Toronto OR Trois-Rivieres OR Vancouver OR Vaughan OR Whitehorse OR Winnipeg OR Wood Buffalo OR Yellowknife) OR ab(canad* OR "british columbia" OR alberta* OR saskatchewan OR manitoba* OR ontario OR quebec OR (new brunswick NOT new jersey) OR nouveau brunswick OR nova scotia OR nouvelle ecosse OR prince edward island OR newfoundland OR labrador OR nunavut OR nwt OR northwest territories OR yukon OR nunavik OR inuvialuit OR Abbotsford OR Airdrie OR Ajax OR Aurora OR Barrie OR Belleville OR Blainville OR Brampton OR Brantford OR Brossard OR Burlington OR Burnaby OR Caledon OR Calgary OR Cape Breton OR Chatham Kent OR Chilliwack OR Clarington OR Coquitlam OR Drummondville OR Edmonton OR Fredericton OR Fort McMurray OR Gatineau OR Granby OR Grande Prairie OR Sudbury OR Guelph OR Halton Hills OR Iqaluit OR Inuvik OR Kamloops OR Kawartha Lakes OR Kelowna OR Kingston OR Kitchener OR Langley OR Laval OR Lethbridge OR Levis OR Longueuil OR Maple Ridge OR Markham OR Medicine Hat OR Milton OR Mirabel OR Mississauga OR Moncton OR Montreal OR Nanaimo OR New Westminster OR Newmarket OR Niagara Falls OR Norfolk County OR North Bay OR North Vancouver OR North Vancouver OR Oakville OR Oshawa OR Ottawa OR Peterborough OR Pickering OR Port Coquitlam OR Prince George OR Quebec City OR Red Deer OR Regina OR Repentigny OR Richmond OR Richmond Hill OR Saanich OR Saguenay OR Saint John OR Saint-Hyacinthe OR Saint-Jean-sur-Richelieu OR Saint-Jerome OR Sarnia OR Saskatoon OR Sault Ste Marie OR Sherbrooke OR St Albert OR St Catharines OR St John's OR Strathcona County OR Surrey OR Terrebonne OR Thunder Bay OR Toronto OR Trois-Rivieres OR Vancouver OR Vaughan OR Whitehorse OR Winnipeg OR Wood Buffalo OR Yellowknife)) AND (ti((("climat* change" OR global-climate* OR "climate event" OR "disaster storm*" OR "global warming" OR "environmental change" OR "greenhouse gas*" OR "greenhouse effect*" OR "carbon emission*" OR "carbon dioxide emission*" OR "CO2 emission*" OR desertifcation OR hurricane* OR cyclone* OR tornado* OR superstorm* OR "dust storm*" OR "storm surge*" OR "ice storm*" OR monsoon* OR "extreme heat" OR "extreme temperature*" OR "extreme cold" OR wildfire* OR "fire disaster*" OR "uncontrolled fire*" OR "sea level rise" OR "permafrost melt" OR "sea level ris*" OR "glacial retreat" OR "ice cap melt*" OR "thermohaline conveyor" OR "extreme precipitation" OR waterlogging OR flood* OR "El Nino" OR "La Nina" OR uv-index OR uv-rays OR ozone hole))) OR ti(((((air OR atmosphere OR gas*) AND (emission* OR immission* OR quality OR pollut* OR vapor* OR vapour* OR purifi* OR fume*))))) OR ti((((dust OR ((industrial OR traffic OR automobile OR diesel of vehicle OR roadway OR motorway OR highway) AND (emit* OR emiss* OR vapor* OR vapour* OR fume*)))))) OR ti((((afterburning OR smog OR electrosmog OR flaring OR ordor OR odour OR "fly ash" OR "fall out" OR "acid rain" OR "acid precipitation" OR "airborne particulate")))) OR ti((("workplace air" OR "factory air" OR "airborne pesticide*" OR "airborne herbicide*" OR "airborne insecticide*" OR "insecticide mist*" OR "pesticide mist*" OR "herbicide mist*"))))

PROSPERO Searched June 7, 2020

#1	((elders OR elderly OR geriatric* OR "old age" OR "senior citizens" OR "older adult*" OR centenarian* OR nonagenarian* OR octogenarian* OR septuagenarian* OR sexagenarian* OR dottering OR decrepit OR tottering	33364	

		OR overaged OR "oldest old" OR pediatric* OR paediatric* OR child* OR newborn* OR congenital* OR infan* OR baby OR babies OR neonat* OR pre-term OR preterm* OR "premature birth*" OR nicu OR preschool* OR pre-school* OR kindergarten* OR kindergarden* OR "elementary school*" OR "nursery school*" OR "day care*" OR schoolchild* OR toddler* OR boy OR boys OR girl* OR "middle school*" OR pubescen* OR juvenile* OR teen* OR youth* OR "high school*" OR adolesc* OR pre-pubesc* OR prepubesc* OR immigrant* OR immigration OR emmigrant* OR emmigration OR refugee* OR "asylum seeker*" OR asylee* OR "displaced person*" OR "incomer*" OR "in comer*" OR "new comer*" OR newcomer* OR childbearing OR childbirth OR pregnan* OR fertile OR fecund OR womanish OR womanly OR maternal OR vulnerable)		
	#2	Saulteaux or Wakashan or Cree or Dene or Inuit or Inuk or Inuvialuit* or Haida or Ktunaxa or Tsimshian or Gitsxan or Nisga'a or Haisla or Heiltsuk or Oweenkeno or Kwakwaka'wakw or Nuu chah nulth or Tsilhqot'i. or Dakelh or Wet'suwet'en or Sekani or Dunne-za or Dene or Tahltan or Kaska or Tagish or Tutchone or Nuxalk or Salish or Stl'atlimc or Nlaka'pamux or Okanagan or Sec wepmc or Tlingit or Anishinaabe or Blackfoot or Nakoda or Tasttine or Tsuu T'inia or Gwich'in or Han or Tagish or Tutchone or Algonquin or Nipissing or Ojibwa or Potawatomi or Innu or Maliseet or Mi'kmaq or Micmac or Passamaquoddy or Haudenosaunee or Cayuga or Mohawk or Oneida or Onodaga or Seneca or Tuscarora or Wyandot or Aboriginal* or Indigenous* or Metis or red road or "on reserve" or off-reserve or First Nation or First Nations or Amerindian	1157	
	#3	"urban indian*" or "urban native*" or "country food*" or "residential school*" or shaman* or "traditional heal*" or "traditional food*" or "medicine man" or "medicine woman" or autochtone*	110	
	#4	arborist* or archaeologist* or fruit picker* or farm labor* or farm labour* or berry pick* or cowboy* or cowgirl* or "deck hand" or dog walker* or farmworker* or fisher* worker* or fisherm?n or firefighter* or fire fighter* or farmer* or farmhand* or forester or flagm* or flagwom* or greens keeper* or grounds keeper* or gardener* or garbagewom* or garbage man or garbage men or garbage women or garbage woman or garbage collector* or garbage worker* or herder* or hunter* or letter carrier* or lifeguard* or landscaper* or mail carrier* or marine biologist* or mariner* or outdoor* work* or outdoor employment* or outdoor construction*	611	
	#5	outdoor job* or outside work* or outside employment* or outside construction* or outside job* or "out of doors work*" or "out of doors employment" or "out of doors job*" or "playground supervisor*"	7	
	#6	power line technician* or ski instructor* or ski patrol* or ranger or rangers or "rig hand*" or sailor* or parks worker* or shepherd* or smoke jumper* or stoop labour*	100	
	#7	stoop labour * or trapper* or tree planter* or vegetable picker* or wildlife biologist*	2	
	#8	"hard to house" or "lack of housing" or "substandard housing" or "unstably housed" or underhoused or "under housed" or squatter* or homeless* or vagabond* or vagrant* or indigent	209	
	#9	#8 OR #7 OR #6 OR #5 OR #4 OR #3 OR #2 OR #1	34431	
	#10	((canad* or "british columbia" or alberta* or saskatchewanwan or manitoba* or ontario or quebec or (new brunswick not new jersey) or nouveau brunswick or nova scotia or nouvelle ecosse or prince edward island or	10531	

		newfoundland or labrador or nunavut or nwt or northwest territories or yukon or nunavik or inuvialuit or Abbotsford or Airdrie or Ajax or Aurora or Barrie or Belleville or Blainville or Brampton or Brantford or Brossard or Burlington or Burnaby or Caledon or Calgary or Cape Breton or Chatham Kent or Chilliwack or Clarington or Coquitlam or Drummondville or Edmonton or Fredericton or Fort McMurray or Gatineau or Granby or Grande Prairie or Sudbury or Guelph or Halton Hills or Iqaluit or Inuvik or Kamloops or Kawartha Lakes or Kelowna or Kingston or Kitchener or Langley or Laval or Lethbridge or Levis or Longueuil or Maple Ridge or Markham or Medicine Hat or Milton or Mirabel or Mississauga or Moncton or Montreal or Nanaimo or New Westminster or Newmarket or Niagara Falls or Norfolk County or North Bay or North Vancouver or North Vancouver or Oakville or Oshawa or Ottawa or Peterborough or Pickering or Port Coquitlam or Prince George or Quebec City or Red Deer or Regina or Repentigny or Richmond or Richmond Hill or Saanich or Saguenay or Saint John or Saint-Hyacinthe or Saint-Jean-sur-Richelieu or Saint-Jerome or Sarnia or Saskatoon or Sault Ste Marie or Sherbrooke or St Albert or St Catharines or St John's or Strathcona County or Surrey or Terrebonne or Thunder Bay or Toronto or Trois-Rivieres or Vancouver or Vaughan or Whitehorse or Winnipeg or Wood Buffalo or Yellowknife or Cambridge or Halifax or Hamilton or London or Victoria or Waterloo or Welland or Whitby or Windsor) not (India or UK or Britain or United Kingdom or England or Australia))		
	#11	((("climat* change" or global-climate* OR "climate event" or "disaster storm*" or "global warming" or "evironmental change" or "greenhouse gas*" OR "greenhouse effect*" OR "carbon emission*" OR "carbon dioxide emission*" OR "CO2 emission*" or desertifcation OR hurricane* OR cyclone* OR tornado* OR superstorm* OR "dust storm*" OR "storm surge*" OR "ice storm*" OR monsoon* or "extreme heat" or "extreme temperature*" or "extreme cold" or wildfire* or "fire disaster*" or "uncontrolled fire*" or "sea level rise" or "permafrost melt" or "sea level ris*" or "glacial retreat" or "ice cap melt*" or "thermohaline conveyor" or "extreme precipitation" or waterlogging or flood* or "El Nino" or "La Nina" or uv-index or uv-rays or ozone hole))):TI	37	
	#12	(((((air or atmosphere or gas*) AND (emission* or immission* or quality or pollut* or vapor* or vapour* or purifi* or fume*))))):TI	122	
	#13	(((((dust or ((industrial or traffic or automobile or diesel of vehicle or roadway or motorway or highway) and (emit* or emiss* or vapor* or vapour* or fume*)))))):TI	9	
	#14	((((afterburning or smog or electrosmog or flaring or ordor or odour or "fly ash" or "fall out" or "acid rain" or "acid precipitation" or "airborne particulate")))):TI	3	
	#15	((("workplace air" or "factory air" or "airborne pesticide*" or "airborne herbicide*" or "airborne insecticide*" or "insecticide mist*" or "pesticide mist*" or "herbicide mist*"))):TI	0	
	#16	#11 OR #12 OR #13 OR #14 OR #15	171	
	#20	#9 AND #10 AND #16	14	

APPENDIX 2: SCOPING REVIEW EXTRACTION FORM

Data Extraction Form

Question Field	Data
Reviewer	*Name*
Authors	*Answer*
Title	*Answer*
Published Year	*Answer*
Journal	*Answer*
What years were the data collected?	*Answer*
What was the study objective(s)?	*Answer*
In which province(s)/territories was the study conducted? (select all that apply)	*Alberta*
	British Columbia
	Manitoba
	New Brunswick
	Newfoundland and Labrador
	Northwest Territories
	Nova Scotia
	Nunavut
	Ontario
	Prince Edward Island
	Quebec
	Saskatchewan
	Yukon
What was the setting? (select one)	*Urban*
	Rural
	Other:
What was the total number of participants/size of the population?	*Answer*
What were the age breakdowns?	*Answer*
What was the sex distribution?	*Answer*
What was the study methodology? (select one)	*Randomized controlled trial*
	Non-randomized experimental study
	Cohort study
	Cross sectional study
	Case control study
	Systematic review
	Qualitative research
	Prevalence study
	Case series
	Case report
	Ecological
	Mixed-methods

	Other:
What type of analyses were employed?	*Answer*
What climatic/environmental variables were investigated? (List variables under headings)	*Temperature*
	Heat wave
	Humidity
	Icy conditions
	Precipitation
	Air pollution
	Drought
	Flood
	Storm (rainstorm, snowstorm, etc.)
	Wild fire
	Other:
How were the climatic variables defined and measured/how was exposure assigned?	*Answer (i.e. list air pollutants and how they were measured)*
What health outcomes were investigated? (List outcomes under heading)	*Asthma, respiratory allergies, airway disease and related mortality*
	Bone fractures/trauma and related mortality
	Cancer and related mortality
	Cardiovascular disease and stroke and related mortality
	Foodborne diseases and nutrition and related mortality
	Heat-related morbidity and mortality
	Mental health and stress-related disorders and related mortality
	Neurological diseases and disorders and related mortality
	Vector-borne and zoonotic diseases and related mortality
	Waterborne diseases and related mortality
	Weather-related morbidity and mortality
	Other:
How were the outcomes measured?	*Answer*
Which vulnerable population(s) was assessed? (select all that apply)	*Older adults*
	Immigrants
What, if any, socioeconomic characteristics did the study include in the analysis?	*Answer*
Did the study explore sex/gender differences?	*Yes*
	No
What interactions were explored, if any?	*Answer*
What were the results?	*Answer*
What are the relevant conclusions?	*Answer*

APPENDIX 3: ICD-9 AND 10TH EDITION CODES FOR HEALTH OUTCOMES

DEFINITIONS

Canadian Institute for Health Information (CIHI) discharge abstract database (DAD): captures data for hospital inpatient discharges.

National Ambulatory Care Reporting System (NACRS): captures data on health service use related to the emergency department, day surgery, outpatient and community-based clinics, rehabilitation facilities, outpatient mental health, and diagnostic imaging services.

Algorithm: Monthly counts of hospital, clinic, and physician visits from January 1, 2015 to December 31, 2018.

Table A3 Outcome Variables and ICD-9 and ICD-10 Codes

Condition	*Category*	ICD-9	ICD-10	Ref.
Date of visit				
Atrial Fibrillation	*Cardiovascular*	427.3	I48.0	[1]
Chronic heart failure	*Cardiovascular*	398.91, 402.01, 402.11, 402.91, 404.01, 404.03, 404.11, 404.13, 404.91, 404.93, 425.4–425.9, 428	I09.9, I25.5, I42.0, I42.5– I42.9, I43, I50	[1]
Myocardial infarction	*Cardiovascular*	410	I21-I22	[1]
Stroke or TIA	*Cardiovascular*	362.3, 430, 431, 433.x1, 434.x1, 435, 436	G45.0-G45.3, G45.8-G45.9, H34.1, I60, I61, I63, I64	[1]
Fall related injury	*Injury*	800-854, 920-924, E880-E888	Outcome codes: S00-T14 Exposure codes: W00-W19	
Spinal cord injury	*Injury*	806 (Fracture of vertebral column) AND 952 (spinal cord injury without evidence of spinal bone injury)	G82.4, S14.0, S14.1, S24.0, S24.1, S34.0, S34.1, S34.3, T91.3	[2]
Traumatic brain injury	*Injury*	800.x, 801.x, 803.x, 804.x, 850.1-5, 850.9, 851.x, 852, 853, 854.1, 950.1-3, 995.55, 959	S01, S02, S04, S06, S07, T01, T02, T04, T06, T90	[2]
Anxiety	*Mental Health*	300.29, 300.00, 300.01, 300.02, 300.09	F40.22, F41.0, F41.1, F41.3, F41.8, F41.9	

Depression	*Mental Health*	296.2, 296.3, 296.5, 300.4, 309, 311	F20.4, F31.3– F31.5, F32, F33, F34.1, F41.2, F43.2	[2]
PTSD	*Mental Health*	309.81	F43.1	
Reaction to severe stress and adjustment disorders	*Mental Health*	309.0, 309.1, 309.24, 309.28, 309.29, 309.3, 309.4, 309.89, 309.9	F43	
Acute upper respiratory infection	*Respiratory*	460, 461, 461.1-461.3, 461.8, 461.9, 462, 463, 464.00, 464.01, 464.1, 465.0, 465.8, 465.9	J00, J01.00, J01.1- J01.3, J01.90, J02.9, J03.90, J04.0, J05.0, J05.10, J06.0, J09.9	
Rhinosinusitis	*Respiratory*	472.0, 473.0, 473.1, 473.2, 473.3, 473.8, 473.9	J31, J32	
Allergic Rhinitis	*Respiratory*	477.0, 477.8, 477.9	J30.1, J30.8, J30.9	
Acute bronchitis	*Respiratory*	466.0	J20	
Bronchiolitis	*Respiratory*	466.11, 466.19, 041.81, 041.5	J21	
Shortness of breath	*Respiratory*	786.05	R06.0	
Wheeze	*Respiratory*	786.07	R06.2	
Pneumonia	*Respiratory*	480.0-480.3, 480.8, 480.9, 487.0, 481, 482.0 - 482.2, 482.40 - 482.42, 482.31, 482.32, 482.39, 482.49, 482.81-482.83, 482.89, 482.9, 483.0, 483.1, 483.8, 484.7, 484.8, 485, 486, 514, 517.1	J12-J18	
Asthma	*Respiratory*	493	J45	[1]
Chronic pulmonary disease (in. COPD)	*Respiratory*	416.8, 416.9, 490–492, 494-505, 506.4, 508.1, 508.8	I27.8, I27.9, J40– J44, J46- J47, J60– J67, J68.4, J70.1, J70.3	[1]

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APPENDIX 4: CLIMATE AND AIR POLLUTION HAZARD DATA

DEFINITIONS

Land Use Regression (LUR) model: uses measures of pollutants and environmental characteristics of an area that influence pollutant distribution in multiple regression equations to predict concentrations at unmeasured locations.

Australian National University Spline (ANUSPLIN): a trivariate thin plate spline smoothing algorithm used for interpolating meteorological data for exposure assignment that has demonstrated higher precision that can meet the needs of climate and ecological models [1,2].

Minimum mortality temperature (MMT): the temperature at which the lowest mortality in a given area occurs. For Edmonton, AB this has been calculated to be 12.8^{o}C [3].

Table A4.1 Climate change and air pollution hazard data dictionary

Hazard	Unit	Years	Description	Source
Average Temperature	^{o}C	2015	Annual average temperature; spatial distribution estimated using ANUSPLIN modelling at the postal code level by CANUE; mean values were calculated and assigned to entire DA by a geographer.	[4,5]
Minimum Temperature	^{o}C	2015	Annual average minimum temperature; spatial distribution estimated using ANUSPLIN modelling at the postal code level by CANUE; mean values were calculated and assigned to entire DA by a geographer.	[4,5]
Maximum Temperature	^{o}C	2015	Annual average difference of maximum and minimum temperatures; spatial distribution estimated using ANUSPLIN modelling at the postal code level by CANUE; mean values were calculated and assigned to entire DA by a geographer.	[4,5]
Diurnal Temperature Range (DTR)	^{o}C	2015	Annual average difference of maximum and minimum temperatures; spatial distribution estimated using ANUSPLIN modelling at the postal code level by CANUE; mean values were calculated and assigned to entire DA by a geographer.	[4,5]
Heat events	Count	2015	A heat event is defined as three or more consecutive days where the average daily temperature >95th percentile of the daily normal average temperature based on the 1985-2015 normal distribution; spatial distribution of the total number of events was estimated using ANUSPLIN modelling at the postal code level by CANUE; mean values were calculated and assigned to entire DA by a geographer.	[4,5]

Annual total precipitation as rain	mm	2015	Total annual precipitation on all days with minimum temperature ≥0°C; spatial distribution estimated using ANUSPLIN modelling at the postal code level by CANUE; mean values were calculated and assigned to entire DA by a geographer.	[4,5]
Annual total precipitation as snow	mm	2015	Total annual precipitation on all days with minimum temperature <0°C; spatial distribution estimated using ANUSPLIN modelling at the postal code level by CANUE; mean values were calculated and assigned to entire DA by a geographer.	[4,5]
Particulate matter with diameter ≤2.5µg (PM$_{2.5}$)	µg/m^3	2015-18	Mean annual ambient concentration of PM$_{2.5}$; spatial distribution at postal code level estimated using satellite and ground monitor data in LUR models (R^2= 0.92); postal code location points were topologically overlaid with DA polygons to assign a concentration to each DA in Edmonton using geometric intersection by a geographer.	[5,6]
Nitrogen dioxide (NO$_2$)	ppb	2015-16	Mean annual ambient concentration of NO$_2$; spatial distribution at postal code level estimated using LUR models (R^2=0.73) that indicated temperature and precipitation were not significant; postal code location points were topologically overlaid with DA polygons to assign a concentration to each DA in Edmonton using geometric intersection by a geographer.	[4,7]
Ozone (O$_3$)	ppb	2015	Annual average of the highest rolling 8-hour average ambient concentration per day for O$_3$; spatial distribution at postal code level estimated using LUR models that accounted for temperature and precipitation (R^2=0.91); postal code location points were topologically overlaid with DA polygons to assign a concentration to each DA in Edmonton using geometric intersection by a geographer.	[5,8,9]
Industrial emissions	tonnes/km^2	2015-18	Mean emissions from the National Pollutant Release Inventory (NPRI). Kernel density estimations of the spread of chemicals within a 10 km radius of all facilities were calculated using the locations of the emitting industrial facilities [42]; mean emissions were averaged within 1km of each DA centroid and assigned to the entire DA by a geographer.	[7]

Table A4.2 National Pollutant Release Inventory (NPRI) chemical substances [8]

Classification *(Examples)*
Core substances *(Ammonia, zinc, methanol, toluene, phosphorus)*
Alternate threshold substances *(Lead, cadmium, arsenic, cobalt, selenium, mercury)*
Polycyclic Aromatic Hydrocarbons (PAHs) *(Phenanthrene, pyrene, chrysene, anthracene, quinolone)*
Dioxins, Furans, and Hexachlorobenzene
Criteria air contaminants *(Nitrogen oxides (NO$_x$), particulate matter (PM), SO$_2$, Volatile Organic Compounds (VOCs))*
Speciated VOCs (if in large quantities)

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DEFINITIONS

Dissemination area (DA): the smallest standard geographic area for which all census data are disseminated across Canada and on average represent 400-700 persons (Edmonton is divided into 1,196 DAs).

Table A5 Community level indicators of vulnerability data dictionary

Indicator	Unit	Description	Source
Average age	Years	Average age per DA at the time of the 2016 Canadian Census.	[1]
≥65 years	%	Percentage of residents in a DA over the age of 65 at the time of the 2016 Canadian Census; calculated by dividing total numbers of older adults by the DA population.	[1]
Males (vs females)	%	Percentage of male residents in a DA at the time of the 2016 Canadian Census; calculated by dividing total numbers of males by the population; percentages over 50% indicated there were more males in the area while percentages under 50% indicated there were more females.	[1]
Total immigrants	%	Percentage of residents in a DA who were immigrants (anyone who is or has been a landed immigrant or permanent resident; includes refugees) at the time of the 2016 Canadian Census; calculated by dividing total numbers of immigrants by the DA population.	[1]
Recent immigrants	%	Percentage of immigrants in a DA who landed ≤10 years (includes refugees) at the time of the 2016 Canadian Census; calculated by dividing the sum of immigrants who landed in Canada between 2006-2016, by the DA population.	[1]
Long-term immigrants	%	Percentage of immigrants in a DA who landed >10 years (includes refugees) at the time of the 2016 Canadian Census; calculated by dividing the sum of immigrants who landed before 2006 by the DA population.	[1]
Economic immigrants	%	Percentage of immigrants in a DA who were admitted in the economic class at the time of the 2016 Canadian Census; calculated by dividing the number of economic immigrants by the DA population.	[1]
Sponsored immigrants	%	Percentage of immigrants in a DA who were admitted in the sponsored class at the time of the 2016 Canadian Census; calculated by dividing the number of sponsored immigrants by the DA population.	[1]

Refugees	%	Percentage of immigrants in a DA who were admitted in the refugee class at the time of the 2016 Canadian Census; calculated by dividing the number of refugees by the DA population.	[1]
Material deprivation score		Factor score quantifying material deprivation per DA; score encapsulates socioeconomic indicators of material deprivation from 2016 Canadian Census data determined from PCA: low income, low education, and low employment-to-population ratio; values range from most privileged to most deprived.	[2,3]
Social deprivation score		Factor score quantifying social deprivation per DA; score encapsulates socioeconomic indicators of social deprivation from 2016 Canadian Census data determined from PCA: separated, divorced or widowed, and living alone or in a single parent family; values range from most privileged to most deprived.	[2,3]
Normalized Difference Vegetation Index (NDVI)		Normalized score quantifying vegetation (greenspace) using satelite imagery; values for Edmonton were calculated using the red and near-infrared bands 4 and 5 respectively from the Landsat 8 satellite image Row 42 Path 23: NDVI = (near-infrared - red) / (near-infrared + red); mean index value within 1km of each DA centroid was assigned to the entire DA by a geographer; increasing values imply greater amounts of green vegetation (range: -1 to +1) (acquired 2018/07/28).	[4]
Active Living Environment (ALE) Index		Index values quantifying favorability for active living environment per DA; values are the sum of the z-scores of four components: intersection density, dwelling density, number of points of interest (i.e. parks, schools, shops, etc.) and transit stops; values near 0 approach the Canadian average with positive values indicating increased favorability.	
Access to social services	n within 1km	Number of active non-profits within 1km of the DA centroid along the road network were calculated for Edmonton by a geographer; larger numbers imply greater geographical access.	[5,6]
Access to healthcare facilities	n within 1km	Number of Alberta Health facilities (includes all functions, ICU, long-term care, emergency) within 1km of the DA centroid along the road network were calculated for Edmonton by a geographer; larger numbers imply greater geographical access.	[7,8]
Access to clinics	n within 1km	Number of doctors offices/clinics within 1km of the DA centroid along the road network were calculated for Edmonton by a geographer; larger numbers imply greater geographical access.	[8,9]
Access to emergency medical services (EMS)	n within 1km, 3km, 5km	Number of EMS locations within 1km, 3km, and 5km (each) of the DA centroid along the road network were calculated for Edmonton by a geographer; longer distances were calculated because only 115 DAs had EMS stations within 1km; larger numbers imply greater geographical access.	[8,9]
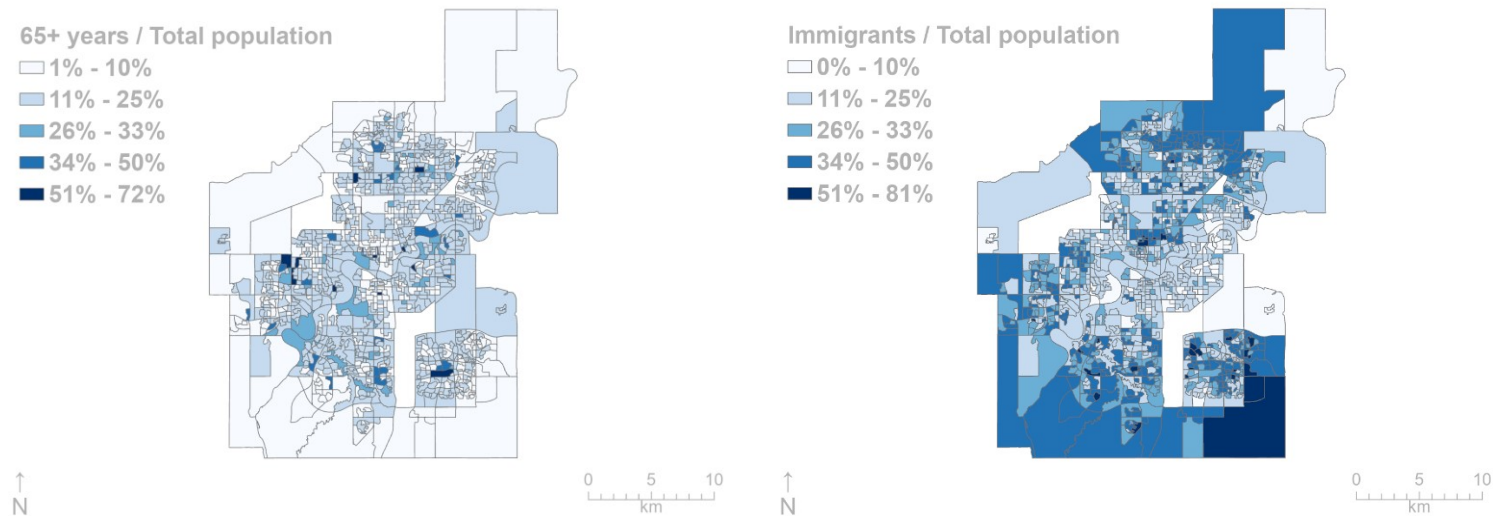
Figure A5. Distribution of older adults (a) and immigrants (b) across Edmonton, AB in 2016 (Nielsen, C.)

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APPENDIX 6: UNIVARIATE RESULTS

Equation A6 Prevalence rate ratio (PRR) calculation

$$\text{Prevalence Rate (PR)} = \frac{\text{Health service use within a DA (exposed or unexposed)}}{\text{Population of the DA}} \qquad \text{(Eq. A6.1)}$$

$$Prevalence\ Rate\ Ratio\ (PRR) = \frac{Prevalence\ Rate\ per\ capita\ exposed}{Prevalence\ Rate\ per\ capita\ unexposed} \qquad (Eq.\ A6.2)$$

Table A6 Unadjusted effects of potential community-level indicators of sensitivity and adaptive capacity on the per-capita rates of cardiovascular, injury, mental, and respiratory health events in Edmonton, AB (2015-18).

Sensitivity and Adaptive Capacity Indicators	Cardiovascular PRR (95%CI)	Injury PRR (95%CI)	Mental Health PRR (95%CI)	Respiratory PRR (95%CI)
Demographics				
Age Variables				
Average Age (years)	1.079***	1.051***	1.034***	1.021***
	(1.071, 1.088)	(1.044, 1.057)	(1.026, 1.042)	(1.015, 1.027)
Over 65 years (%)	1.048***	1.030***	1.022***	1.016***
	(1.041, 1.054)	(1.026, 1.034)	(1.016, 1.028)	(1.011, 1.020)
Over 75 years (%)	1.067***	1.052***	1.036***	1.024***
	(1.057, 1.078)	(1.045, 1.060)	(1.026, 1.045)	(1.017, 1.031)
Over 85 years (%)	1.147***	1.139***	1.090***	1.056***
	(1.116, 1.180)	(1.118, 1.160)	(1.064, 1.116)	(1.038, 1.074)
Males (%)	0.996	1.023***	1.004	1.004
	(0.981, 1.010)	(1.013, 1.033)	(0.991, 1.018)	(0.993, 1.014)
Immigrant Status Variables				
Immigrants (%)	0.986***	0.994***	0.990***	1.000
	(0.983, 0.990)	(0.992, 0.997)	(0.986, 0.993)	(0.997, 1.003)
Long-term Immigrants (<10 years) (%)	0.997	0.995***	0.988***	1.002
	(0.991, 1.003)	(0.990, 0.999)	(0.983, 0.994)	(0.998, 1.006)
Recent Immigrants (≤10 years) (%)	0.977***	0.995***	0.992***	0.998
	(0.973, 0.982)	(0.991, 0.998)	(0.987, 0.996)	(0.995, 1.002)
Refugees (%)	0.987***	1.016***	1.010***	1.020***
	(0.978, 0.995)	(1.010, 1.023)	(1.002, 1.018)	(1.014, 1.026)
Sponsored Immigrants (%)	0.971***	0.989***	0.981***	1.001
	(0.961, 0.980)	(0.982, 0.997)	(0.972, 0.990)	(0.994, 1.009)
Economic Immigrants (%)	0.973***	0.978***	0.976***	0.988***
	(0.968, 0.979)	(0.974, 0.982)	(0.971, 0.981)	(0.984, 0.991)
Material and Social Deprivation				
Material Deprivation Index Score (IQR = 0.056)	1.038	1.150***	1.161***	1.211***
	(0.978, 1.102)	(1.102, 1.200)	(1.099, 1.227)	(1.163, 1.260)
Social Deprivation Index Score (IQR = 0.056)	1.100***	1.287***	1.275***	1.072***
	(1.037, 1.166)	(1.234, 1.342)	(1.207, 1.347)	(1.029, 1.117)

Urban Environment				
Greenness (NDVI)	0.900***	0.854***	0.879***	0.946***
	(0.852, 0.950)	(0.822, 0.888)	(0.834, 0.926)	(0.911, 0.982)
Active Living Environment Index	0.983	1.096***	1.047***	0.982***
	(0.946, 1.021)	(1.065, 1.127)	(1.009, 1.087)	(0.955, 1.009)
Access to Health and Social Services				
Social Services				
Number within 1km, n	1.000	1.002***	1.001***	1.000
	(0.999, 1.001)	(1.001, 1.003)	(1.000, 1.002)	(0.999, 1.000)
Healthcare Facilities				
Number within 1km, n	1.065***	1.241***	1.103***	1.087***
	(1.005, 1.128)	(1.193, 1.291)	(1.045, 1.165)	(1.046, 1.130)
Physician Clinics				
Number within 1km, n	1.002***	1.010***	1.005***	1.002***
	(0.999, 1.005)	(1.008, 1.013)	(1.002, 1.008)	(1.000, 1.004)
Emergency Medical Services				
Number within 1km, n	1.082	1.518***	1.367***	1.165***
	(0.933, 1.254)	(1.363, 1.691)	(1.190, 1.571)	(1.051, 1.291)
Number within 3km, n	1.062***	1.218***	1.143***	1.051***
	(1.000, 1.128)	(1.165, 1.273)	(1.080, 1.210)	(1.008, 1.095)
Number within 5km, n	1.072***	1.162***	1.141***	1.051***
	(1.036, 1.110)	(1.134, 1.190)	(1.105, 1.178)	(1.026, 1.075)
Climate and Air Pollution Hazards				
Heat events (2015, ANUSPLIN)	0.883***†	0.936***	0.866***	0.918***
(IQR = 0.711 Events)	(0.843, 0.924)	(0.902, 0.972)	(0.827, 0.906)	(0.888, 0.949)
Days meeting heath warning threshold (2015-18)	1.054***	1.258***	1.055***	0.999
(IQR = 5.352 Days)	(0.992, 1.120)	(1.205, 1.313)	(0.999, 1.115)	(0.958, 1.042)
Number of Days > MMT (2015-18)	1.035***	1.162***	1.012	0.996
(IQR = 8.800 Days)	(0.991, 1.081)	(1.127, 1.199)	(0.973, 1.053)	(0.966, 1.027)
Number of Days < MMT (2015-18)	0.968***†	0.859***	0.989	1.006
(IQR = 8.854 Days)	(0.926, 1.012)	(0.831, 0.887)	(0.949, 1.030)	(0.975, 1.037)
Min. Temp. (2015, ANUSPLIN)	1.070***	1.128***	1.104***	1.047***
(IQR = 0.118^{o}C)	(1.017, 1.127)	(1.087, 1.172)	(1.051, 1.160)	(1.012, 1.084)
Max. Temp. (2015, ANUSPLIN)	1.021	1.168***	1.102***	1.012
(IQR = 0.112^{o}C)	(0.962, 1.084)	(1.118, 1.221)	(1.041, 1.166)	(0.972, 1.054)
Average Temp. (2015, ANUSPLIN)	1.048***	1.138***	1.099***	1.031***
(IQR = 0.098^{o}C)	(0.997, 1.102)	(1.098, 1.180)	(1.048, 1.153)	(0.997, 1.066)
Diurnal Temp. Range (2015, ANUSPLIN)	0.887***	0.977†	0.941***	0.911***
(IQR = 0.109^{o}C)	(0.823, 0.957)	(0.921, 1.036)	(0.874, 1.013)	(0.865, 0.960)
Rain (2015, ANUSPLIN)	0.774***	0.715***	0.664***	0.849***
(IQR = 5.202 mm)	(0.715, 0.838)	(0.676, 0.758)	(0.619, 0.713)	(0.805, 0.895)
Snow (2015, ANUSPLIN)	1.050***	1.016	1.039***	1.029***
(IQR = 1.634 mm)	(0.993, 1.110)	(0.972, 1.061)	(0.984, 1.097)	(0.990, 1.069)
PM$_{2.5}$ (2015-18, LUR)	1.001	1.003***	1.007***	1.002***
(IQR = 0.845 µg/m^3)	(0.997, 1.005)	(1.000, 1.006)	(1.004, 1.010)	(0.999, 1.004)
Industrial emissions (2015-18, NPRI)	1.148***	1.226***	1.188***	1.007

(IQR = 3.800 tonnes/km^2)	(1.082, 1.218)	(1.171, 1.283)	(1.119, 1.260)	(0.966, 1.049)
O$_3$ (2015, LUR))	1.210***	1.255***	1.229***	1.114***
(IQR = 1.730 ppb)	(1.153, 1.270)	(1.213, 1.299)	(1.174, 1.287)	(1.078, 1.151)
NO$_2$ (2015-16, LUR)	0.787***	0.740***	0.706***	0.857***†
(IQR = 3.901 ppb)	(0.729, 0.849)	(0.699, 0.783)	(0.658, 0.759)	(0.813, 0.903)
Seasonality (% events during April-September)	1.120***	1.158***	1.194***	1.098***
	(1.079, 1.164)	(1.126, 1.192)	(1.151, 1.238)	(1.070, 1.127)

***p<0.20; †Constant insignificant; *ANUSPLIN climate models, **Land Use Regression models; Heat threshold – maximum temperature is >29°C and the minimum temperature is >14°C; MMT – Minimum Mortality Temperature for Edmonton.

APPENDIX 7: RESIDUAL PLOTS

CARDIOVASCULAR HEALTH EVENTS
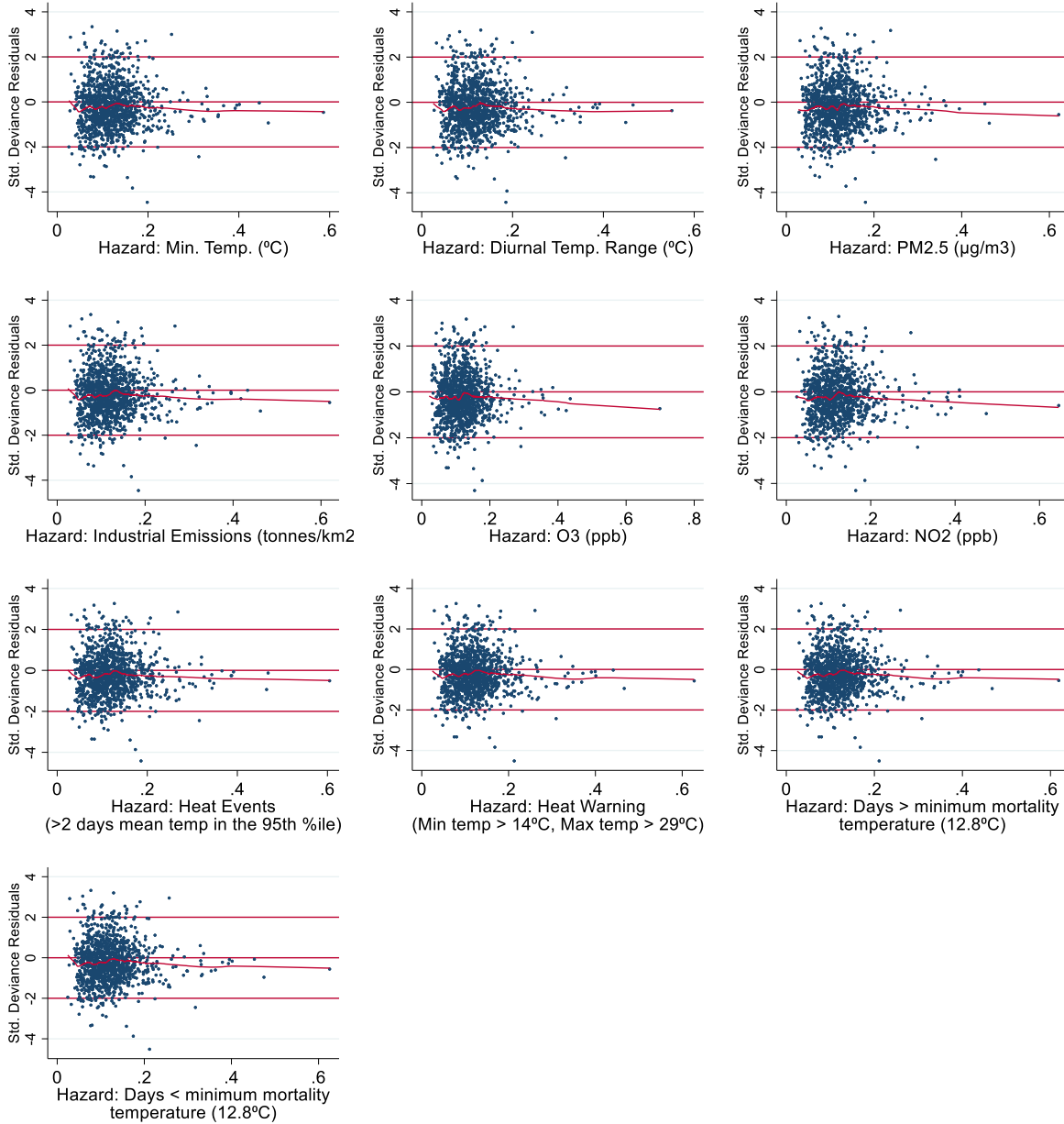
Figure A7.1 Standardized deviance residuals vs predicted rate of cardiovascular health events plots with locally weighted scatterplot smoothing lines for hazard health-impact models. Each adjusted for average age and percentage of total immigrants, social deprivation, greenness, seasonality, and the number of healthcare facilities and clinics within 1km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).
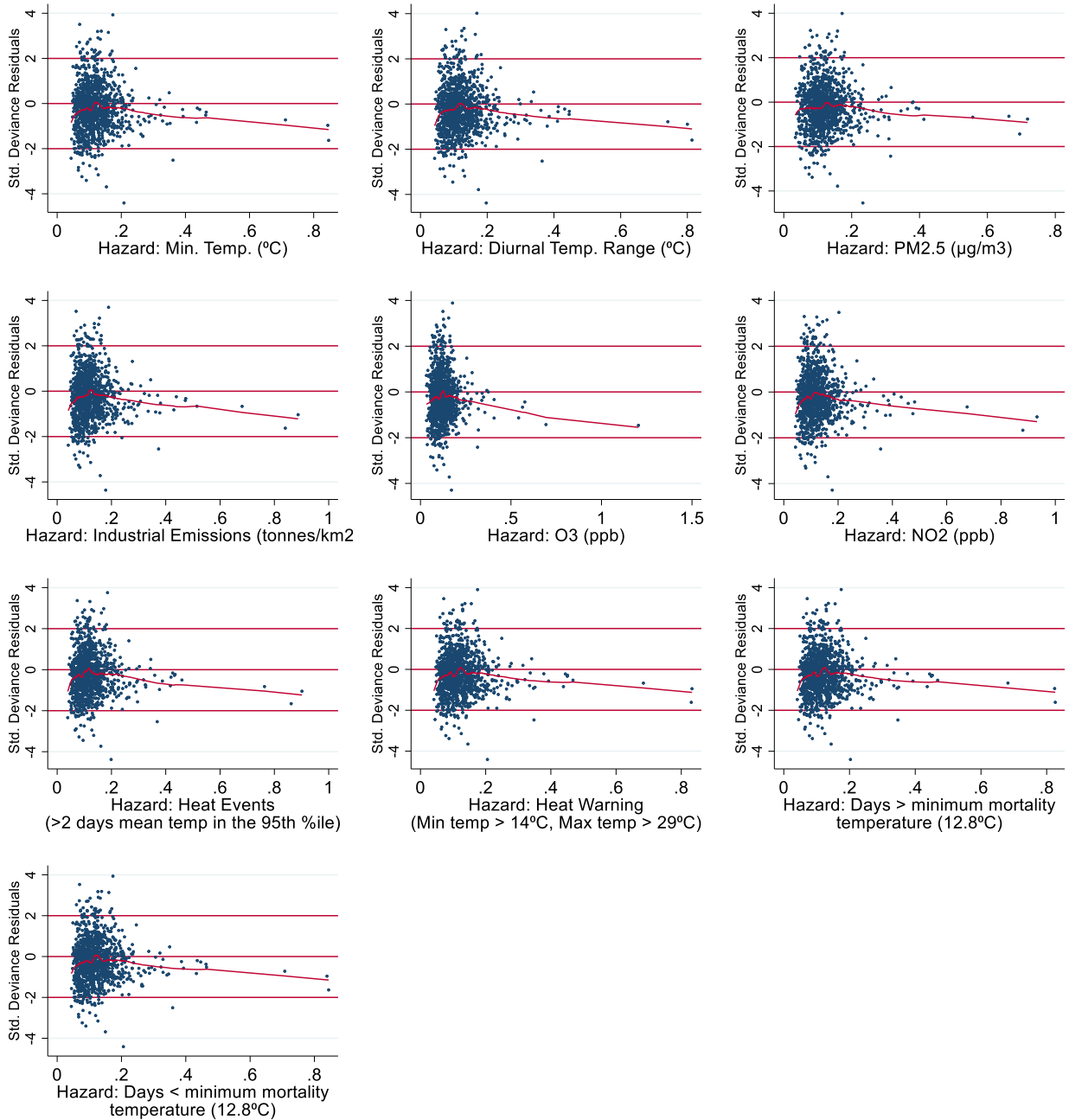
Figure A7.2 Standardized deviance residuals vs predicted rate of cardiovascular health events plots with locally weighted scatterplot smoothing lines for hazard health-impact models. Each adjusted for percentage of older adults and total immigrants, social deprivation, greenness, seasonality, and the number of healthcare facilities and clinics within 1km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).
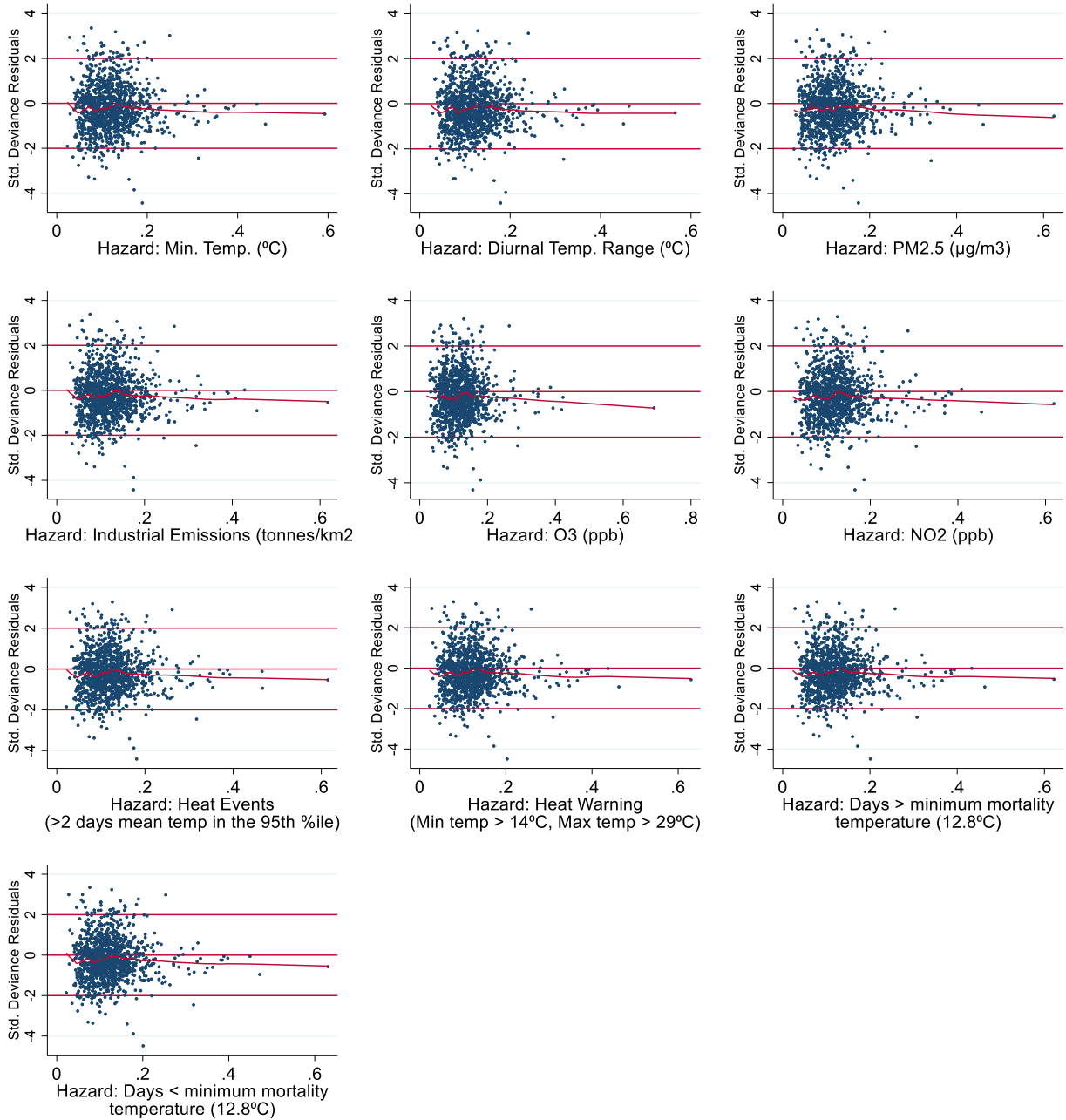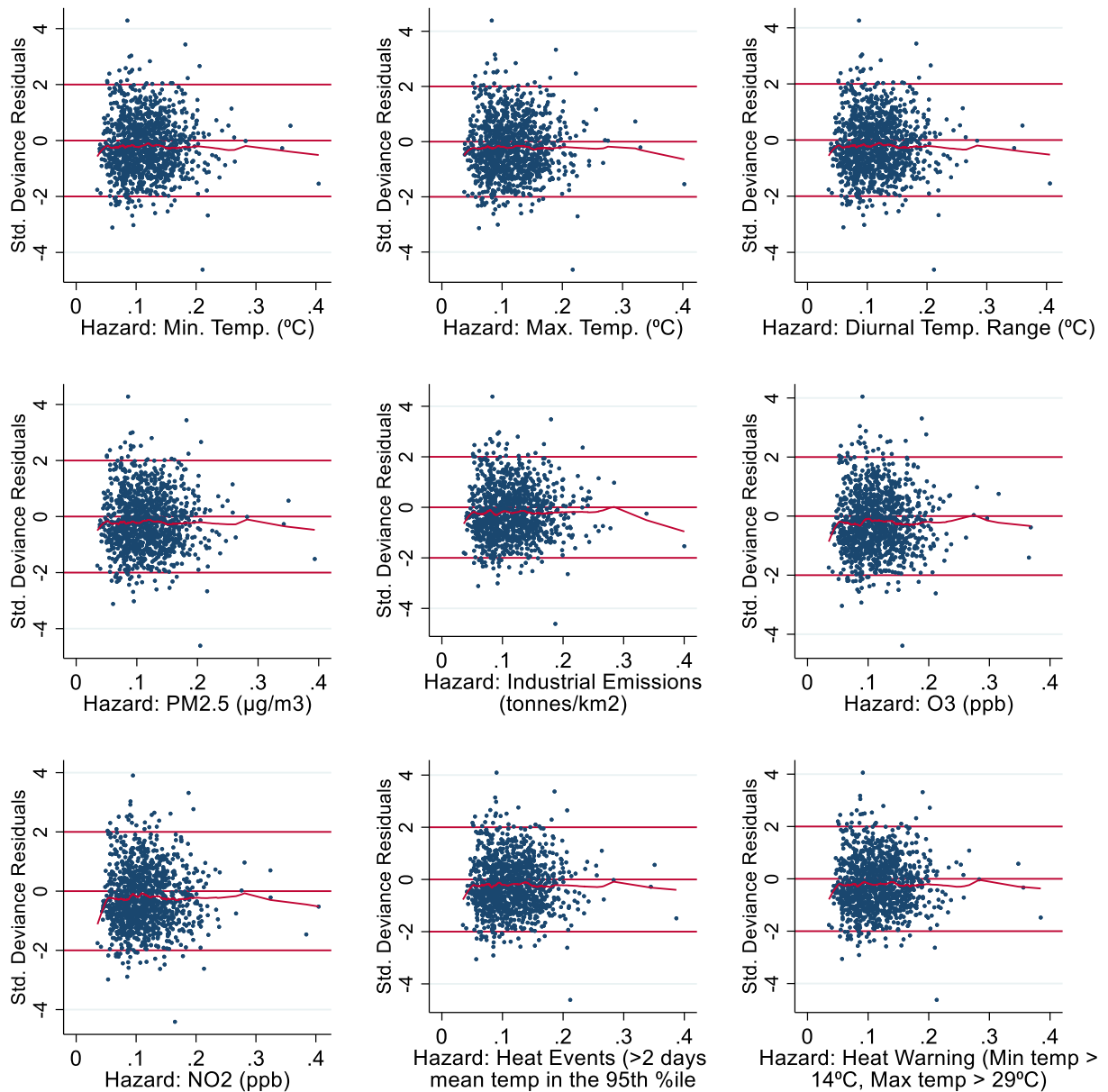
Figure A7.3 Standardized deviance residuals vs predicted rate of cardiovascular health events plots with locally weighted scatterplot smoothing lines for hazard health-impact models. Each adjusted for average age, the percentage of economic immigrants, social deprivation, greenness, seasonality, and the number of healthcare facilities and clinics within 1km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).
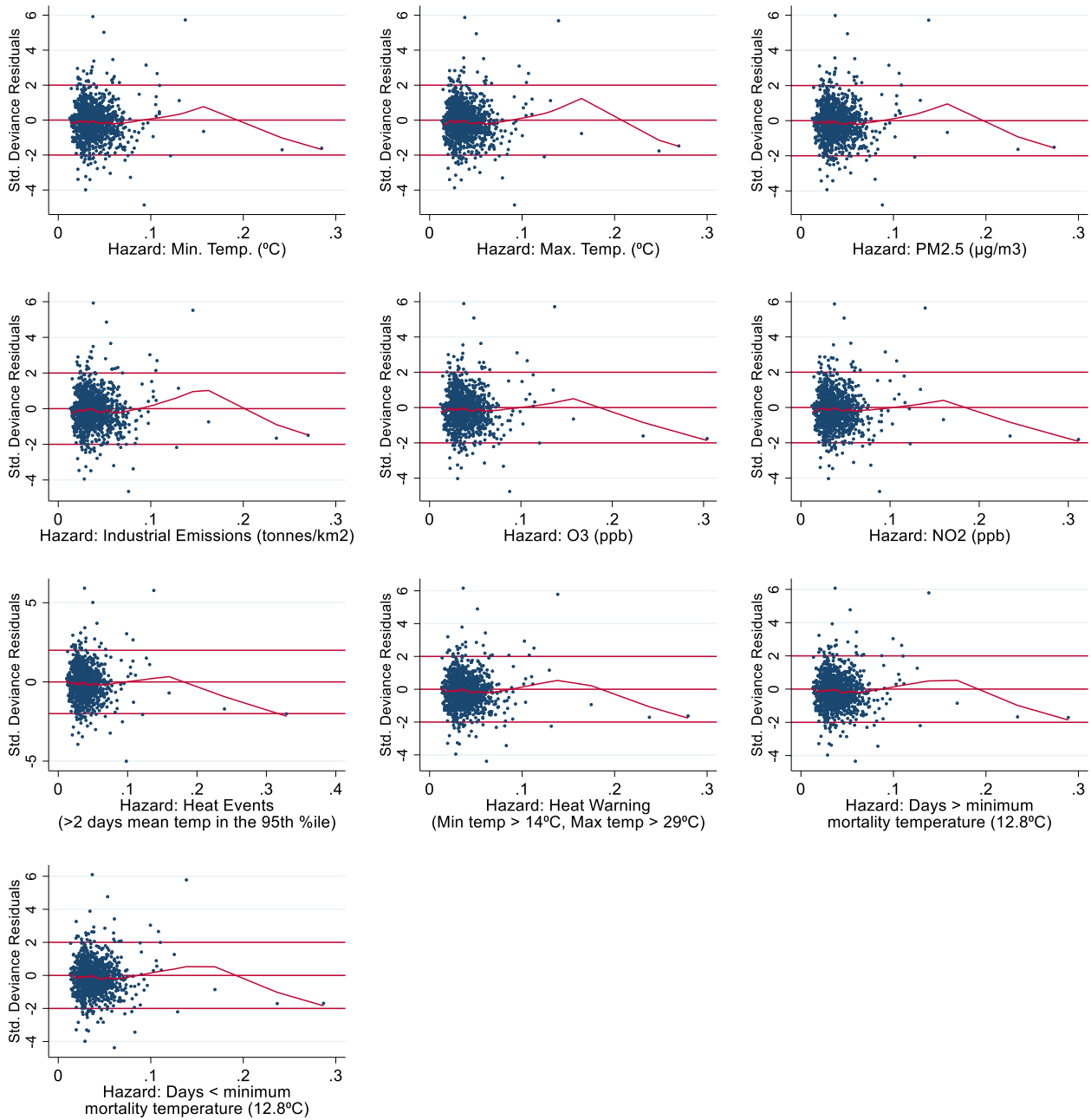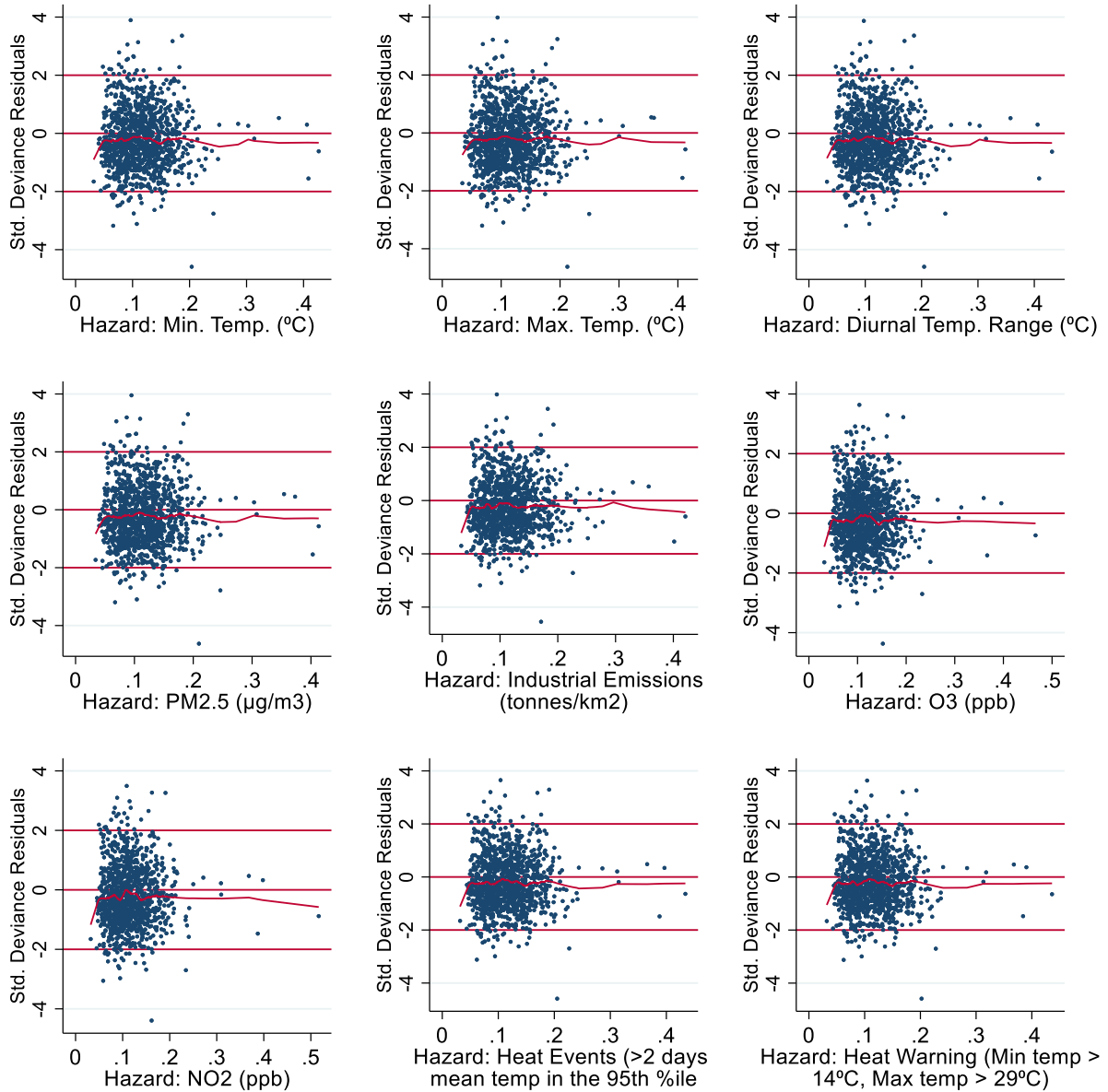
Figure A7.4 Standardized deviance residuals vs predicted rate of injuries plots with locally weighted scatterplot smoothing lines for hazard health-impact models. Each adjusted for average age, the percentage of total immigrants, material and social deprivation, Active Living Environment, seasonality, the number of healthcare facilities, clinics, and social services within 1km, and the number of EMS within 3km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).
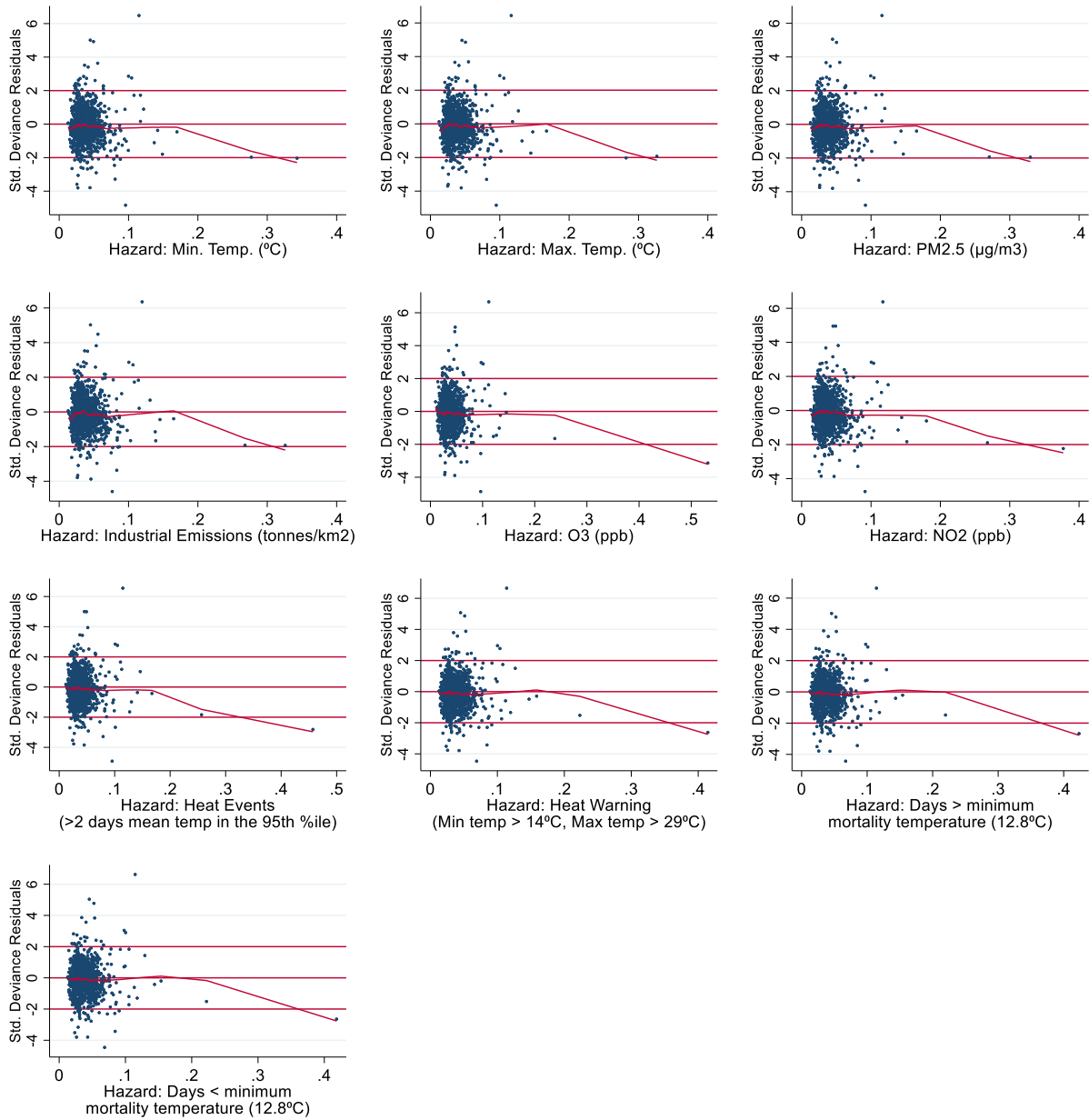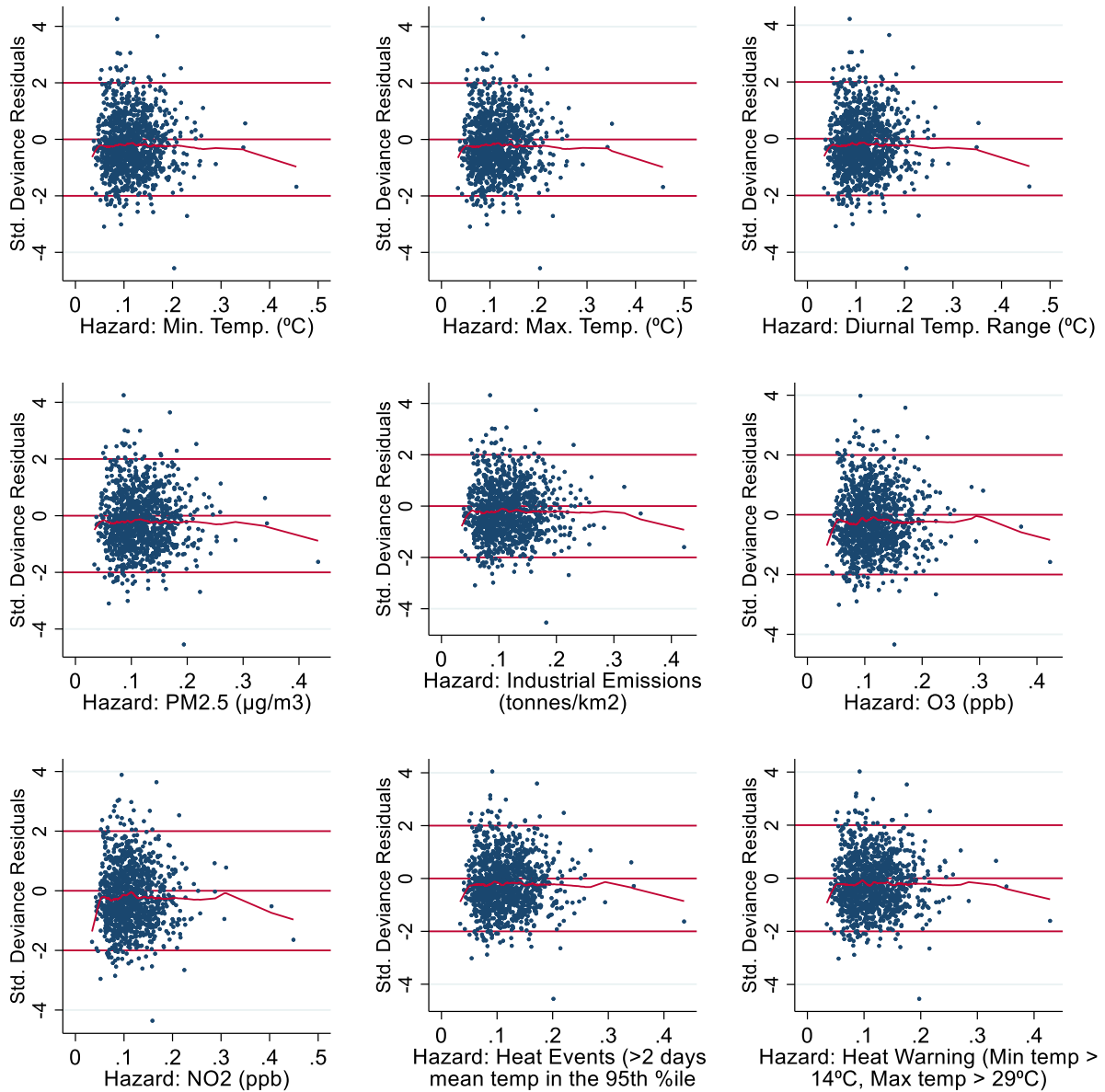
Figure A7.5 Standardized deviance residuals vs predicted rate of injuries plots with locally weighted scatterplot smoothing lines for hazard health-impact models. Each adjusted for the percentage of older adults and total immigrants, material and social deprivation, Active Living Environment, seasonality, the number of healthcare facilities, clinics, and social services within 1km, and the number of EMS within 3km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).
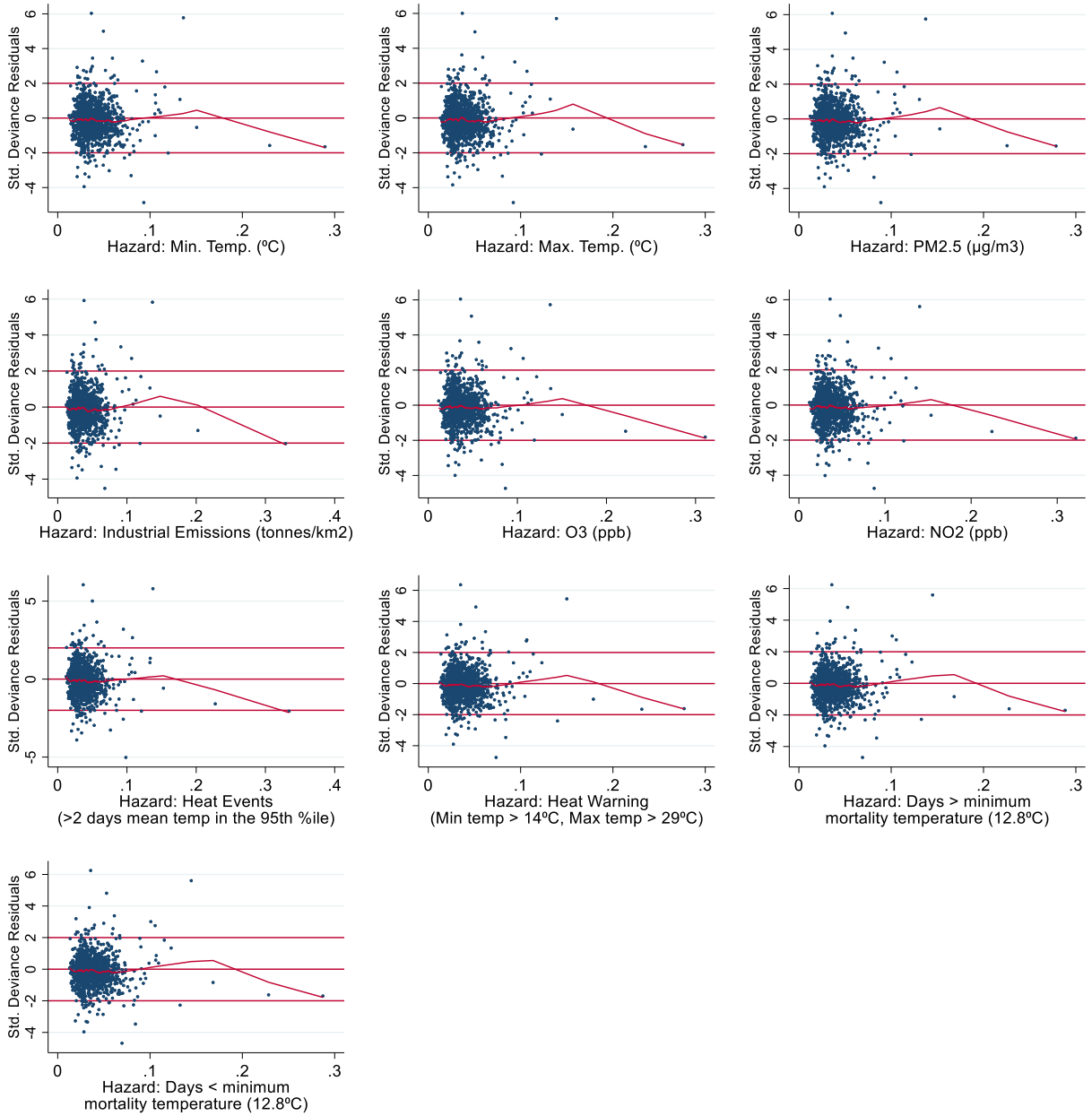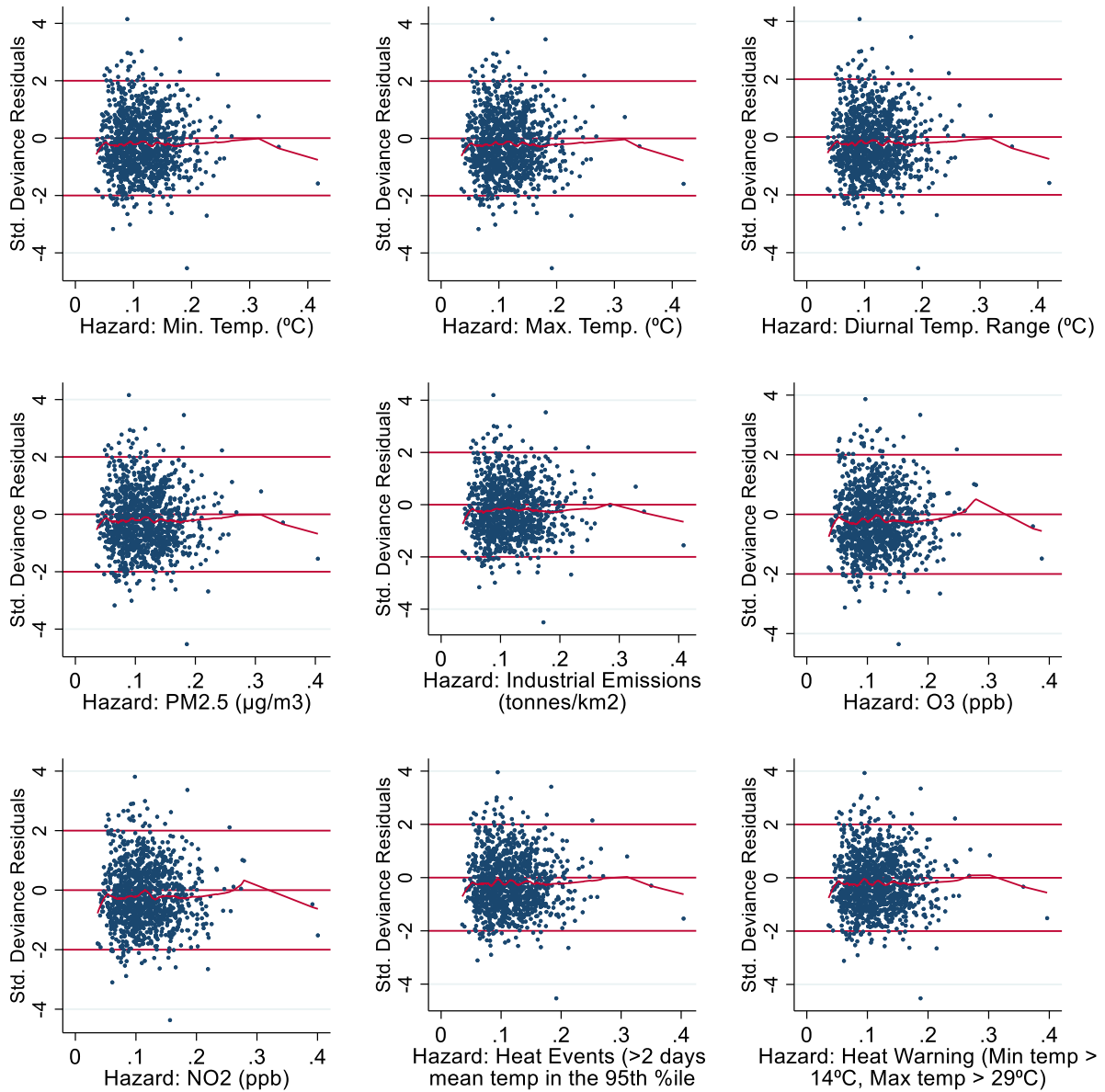
Figure A7.6 Standardized deviance residuals vs predicted rate of injuries plots with locally weighted scatterplot smoothing lines for hazard health-impact models. Each adjusted for average age, the percentage of long term total immigrants, material and social deprivation, Active Living Environment, seasonality, the number of healthcare facilities, clinics, and social services within 1km, and the number of EMS within 3km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).
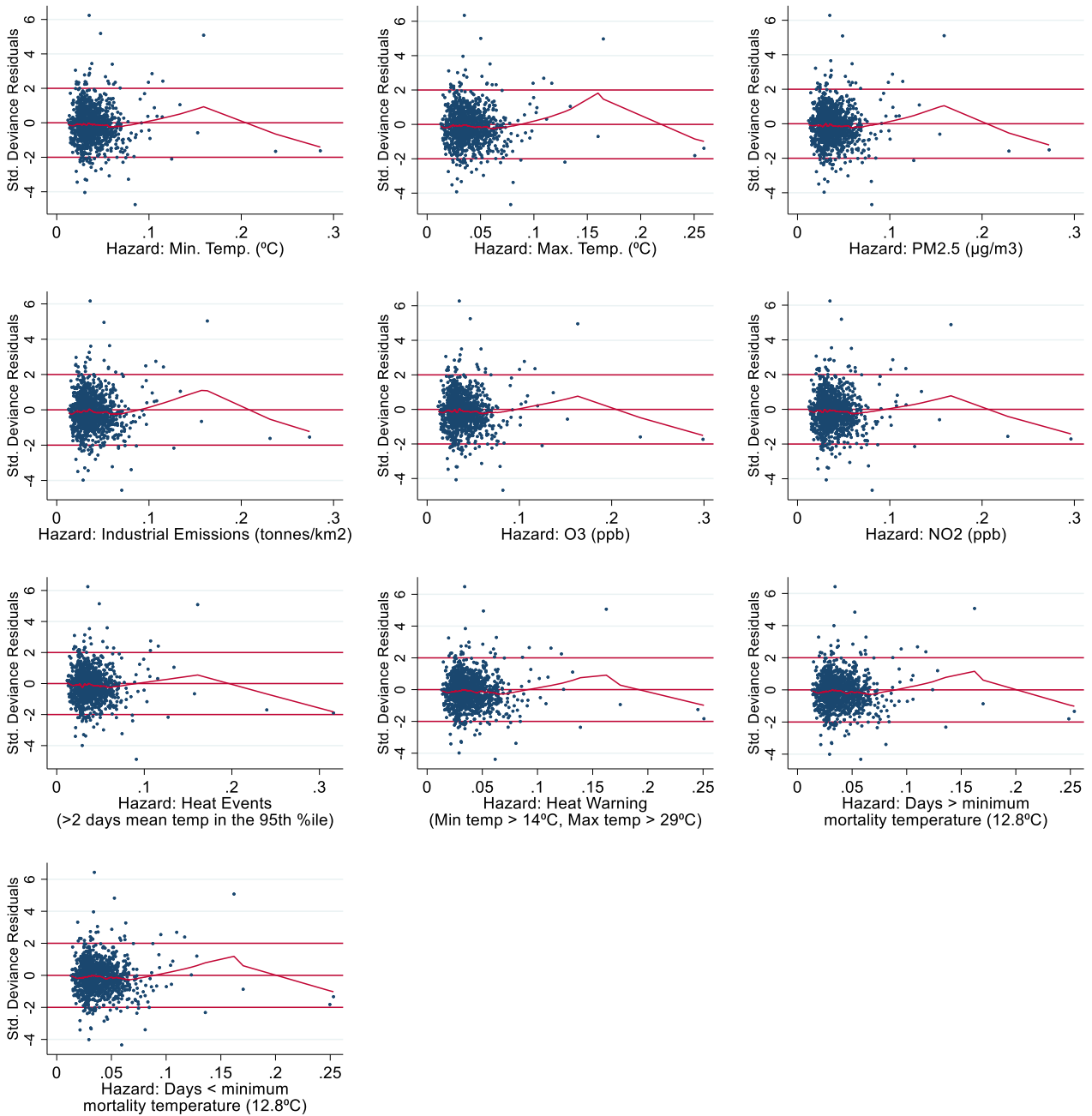
Figure A7.7 Standardized deviance residuals vs predicted rate of injuries plots with locally weighted scatterplot smoothing lines for hazard health-impact models. Each adjusted for average age, the percentage of refugees and economic immigrants, material and social deprivation, Active Living Environment, seasonality, the number of healthcare facilities, clinics, and social services within 1km, and the number of EMS within 3km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).
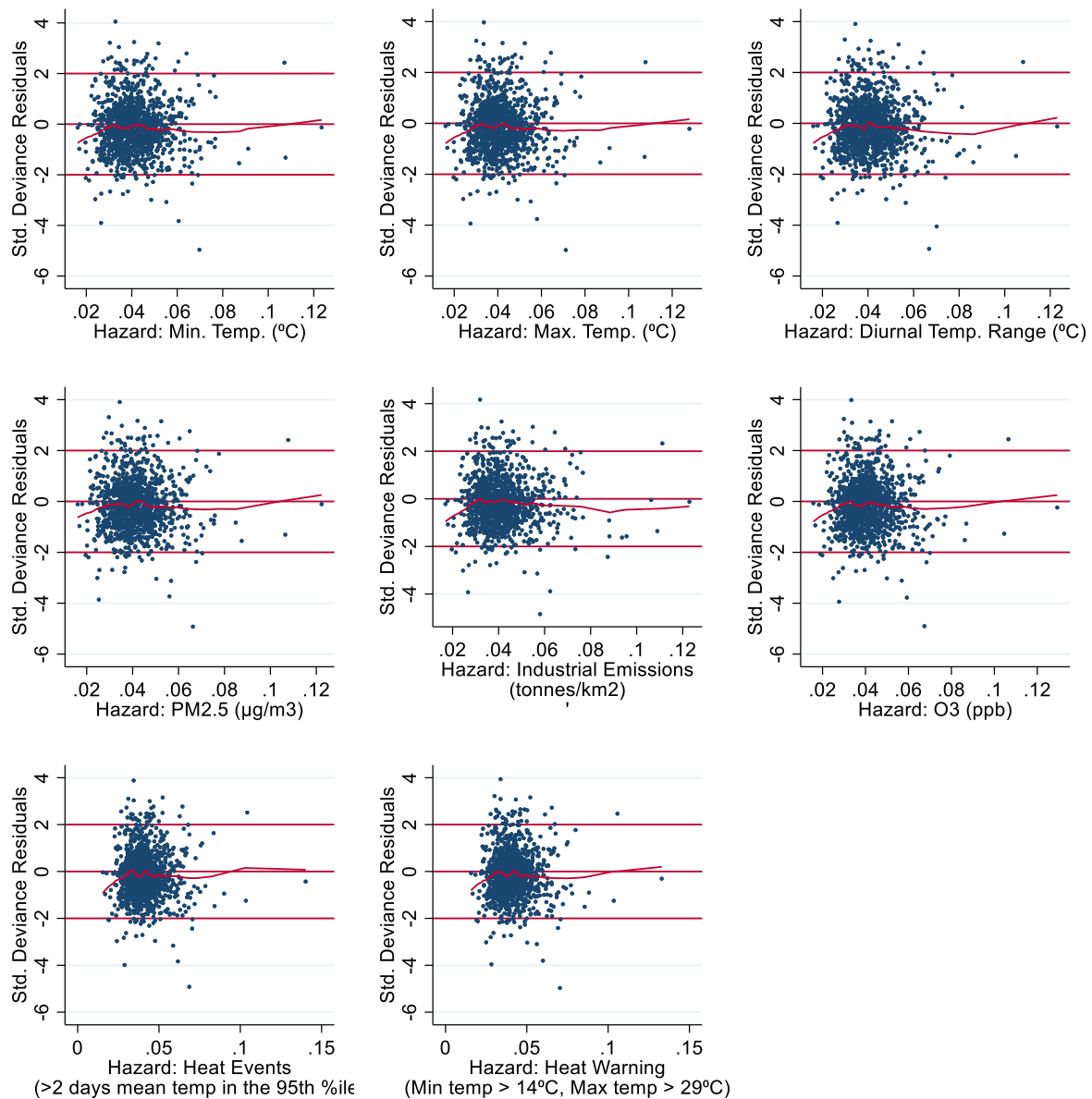
Figure A7.8 Standardized deviance residuals vs predicted rate of mental health events plots with locally weighted scatterplot smoothing lines for hazard mental health-impact models. Each adjusted for average age, percentage of total immigrants, material and social deprivation, greenness (ndvi), seasonality, and the number of clinics and social services within 1km, and the number of EMS within 5km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm)
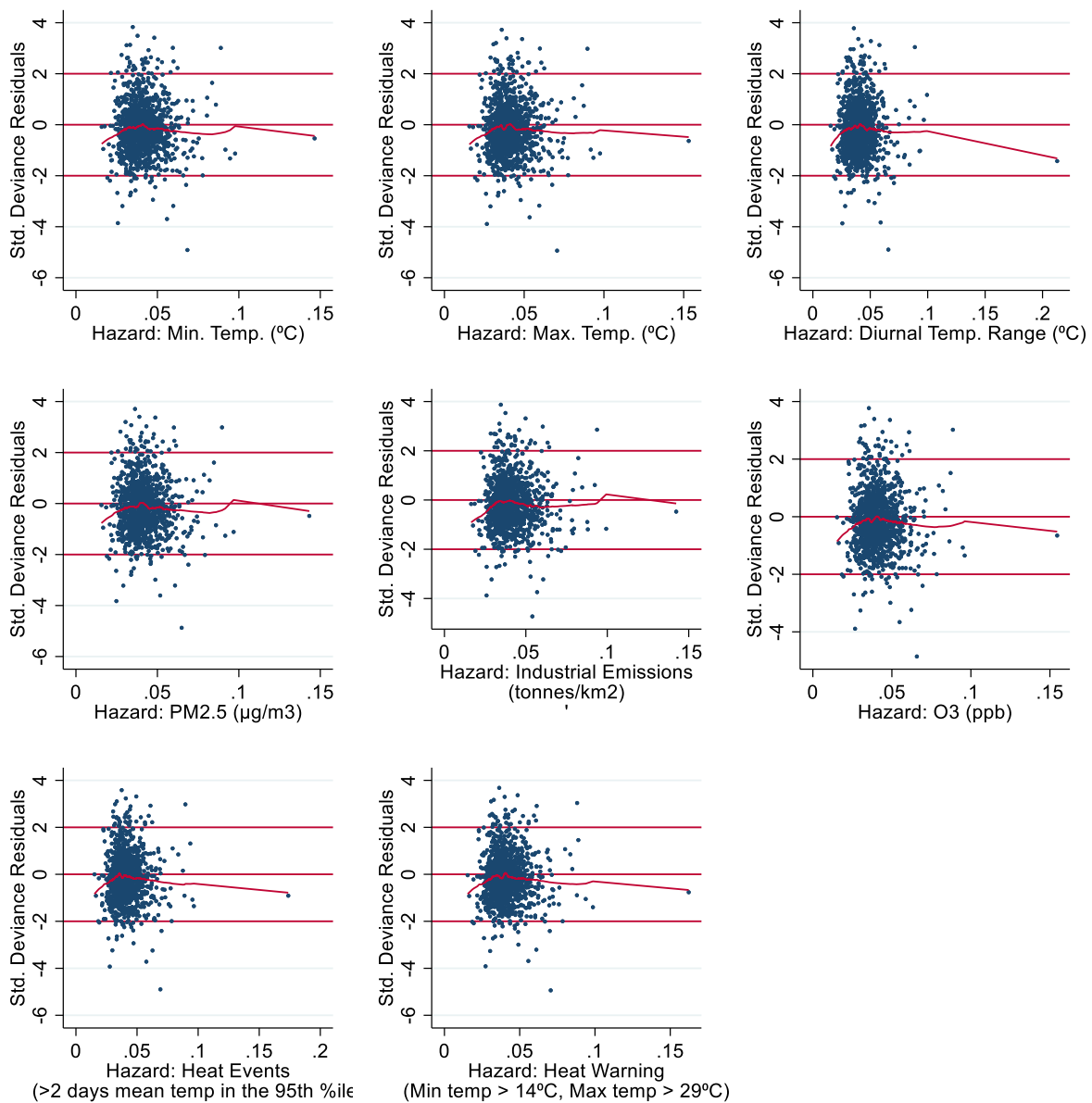
Figure A7.9 Standardized deviance residuals vs predicted rate of mental health events plots with locally weighted scatterplot smoothing lines for hazard mental health-impact models. Each adjusted for the percentage of older adults and total immigrants, material and social deprivation, greenness (ndvi), seasonality, and the number of clinics and social services within 1km, and the number of EMS within 5km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).

Figure A7.10 Standardized deviance residuals vs predicted rate of mental health events plots with locally weighted scatterplot smoothing lines for hazard mental health-impact models. Each adjusted for average age, the percentage of recent immigrants (<10 years since immigrating), material and social deprivation, greenness (ndvi), seasonality, and the number of clinics and social services within 1km, and the number of EMS within 5km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm)

Figure A7.11 Standardized deviance residuals vs predicted rate of mental health events plots with locally weighted scatterplot smoothing lines for hazard mental health-impact models. Each adjusted for average age, the percentage of economic immigrants, material and social deprivation, greenness (ndvi), seasonality, and the number of clinics and social services within 1km, and the number of EMS within 5km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).

Figure A7.13 Standardized deviance residuals vs predicted rate of respiratory health events plots with locally weighted scatterplot smoothing lines for hazard mental health-impact models. Each adjusted for average age, the percentage of refugees, material and social deprivation, greenness (NDVI), Active Living Environment, seasonality, and the number of healthcare facilities and clinics within 1km, and the number of EMS within 5km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm)

Figure A7.14 Standardized deviance residuals vs predicted rate of respiratory health events plots with locally weighted scatterplot smoothing lines for hazard mental health-impact models. Each adjusted for the percentage of older adults and refugees, material and social deprivation, greenness (NDVI), Active Living Environment, seasonality, and the number of healthcare facilities and clinics within 1km, and the number of EMS within 5km; LURs for NO2 and O3 accounted for precipitation, all other hazard models adjusted for rain (mm) and snow (mm).

# APPENDIX 8: EFFECT MODIFICATION EXAMPLES IN FULLY ADJUSTED HEALTH IMPACT MODELS
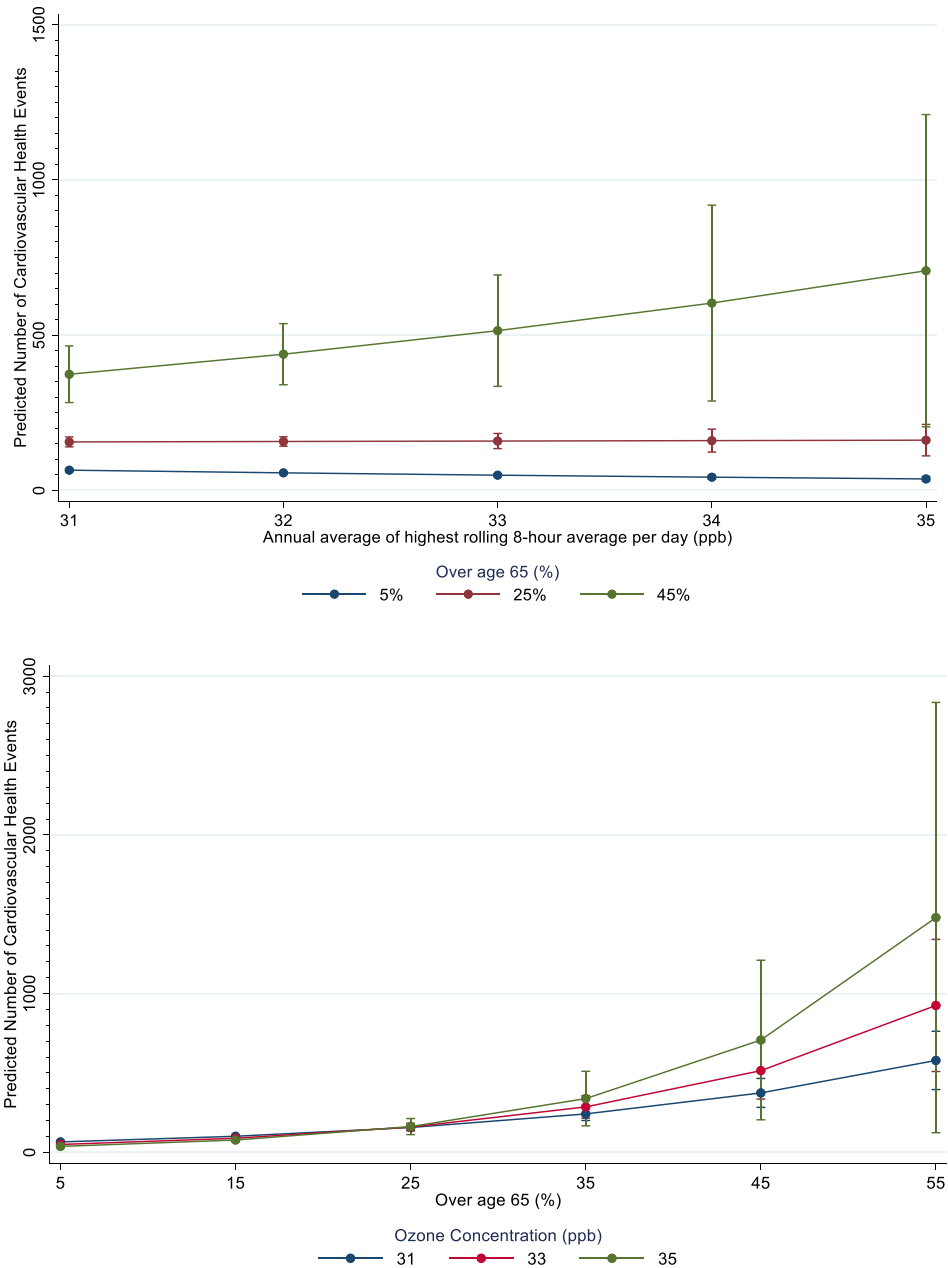
Figure A8.1 Predictive margins with 95% confidence intervals for the effect of a) ozone at increasing percentages of older adults and b) the percentage of older adults at increasing concentrations of ozone on the predicted number of cardiovascular health events in Edmonton, AB (2015-18); model further adjusted for percentage of total immigrants, social deprivation, greenness, seasonality, and the number of healthcare facilities and clinics within 1km.
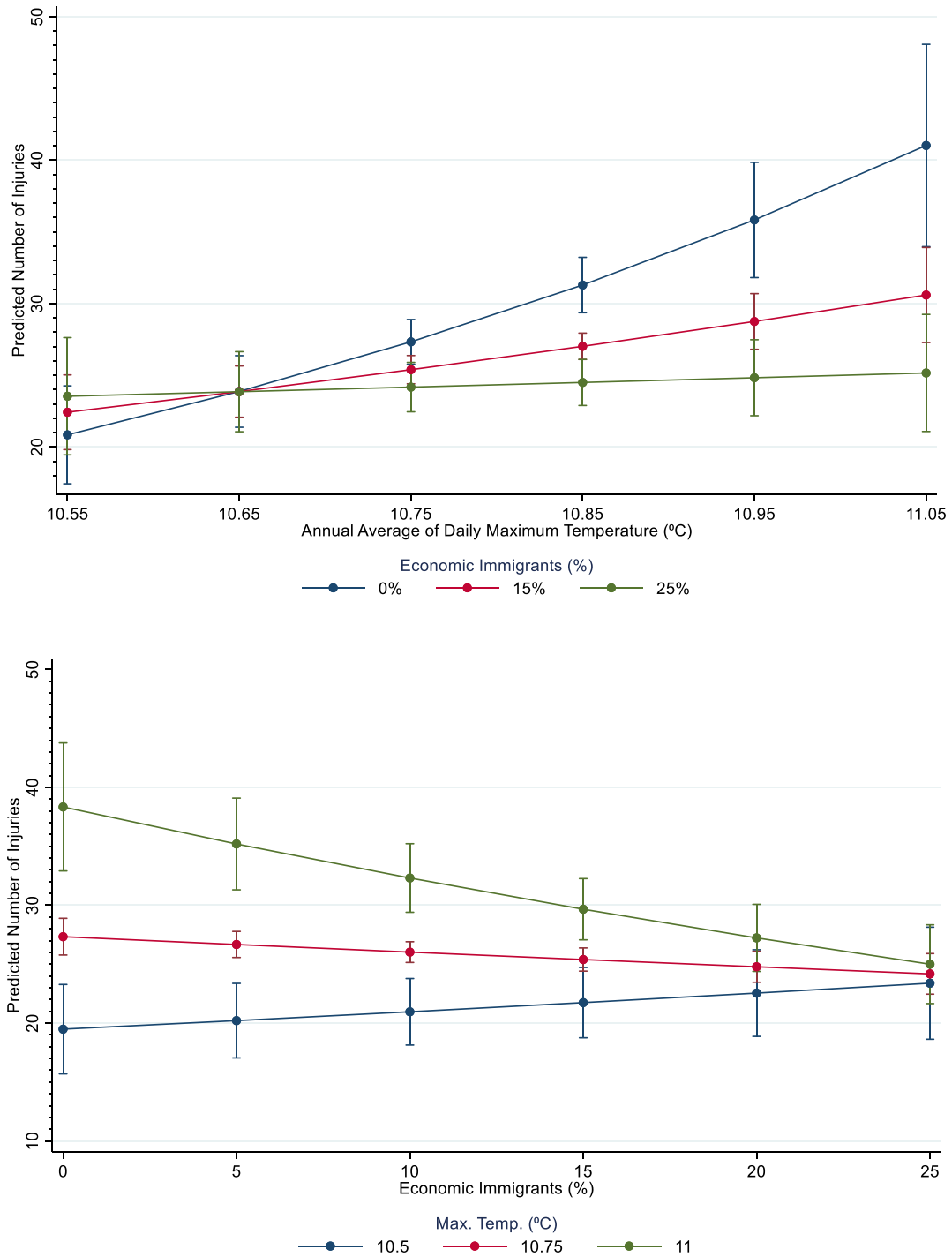
Figure A8.2 Predictive margins with 95% confidence intervals for the effect of a) maximum temperature (⁰C) at increasing percentages of economic immigrants and b) the percentage of economic immigrants at increasing maximum temperatures (⁰C) on the predicted number of injury events in Edmonton, AB (2015-18); model further adjusted for precipitation, average age, percentage of refugees, material and social deprivation, Active Living Environment, seasonality, the number of emergency medical services within 3km, and the number of healthcare facilities and clinics within 1km.
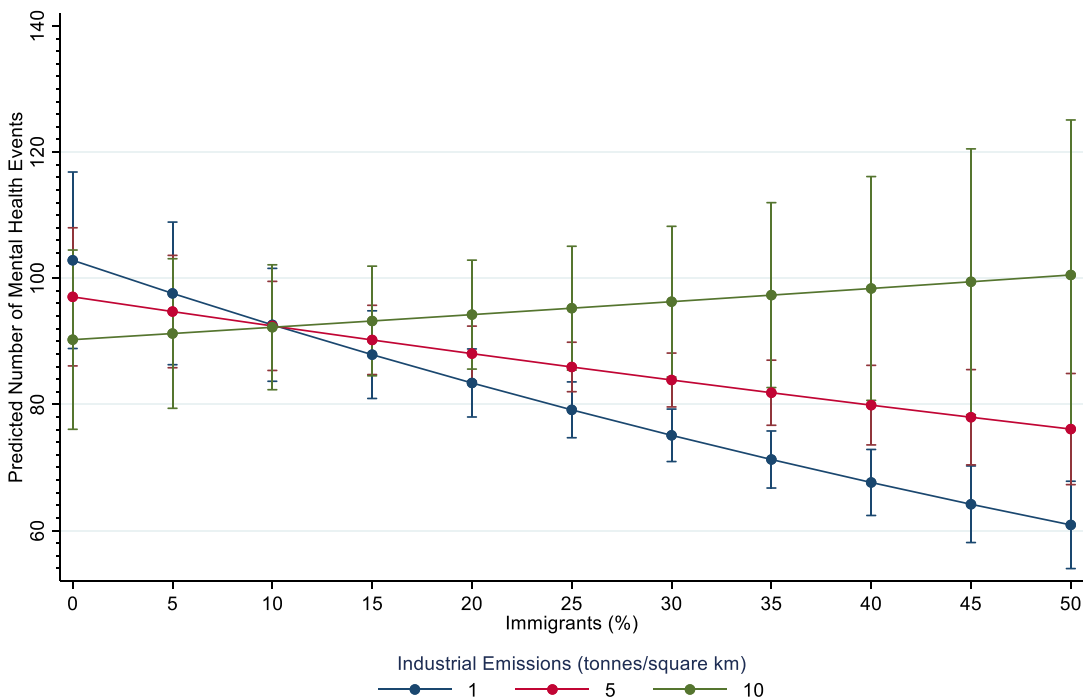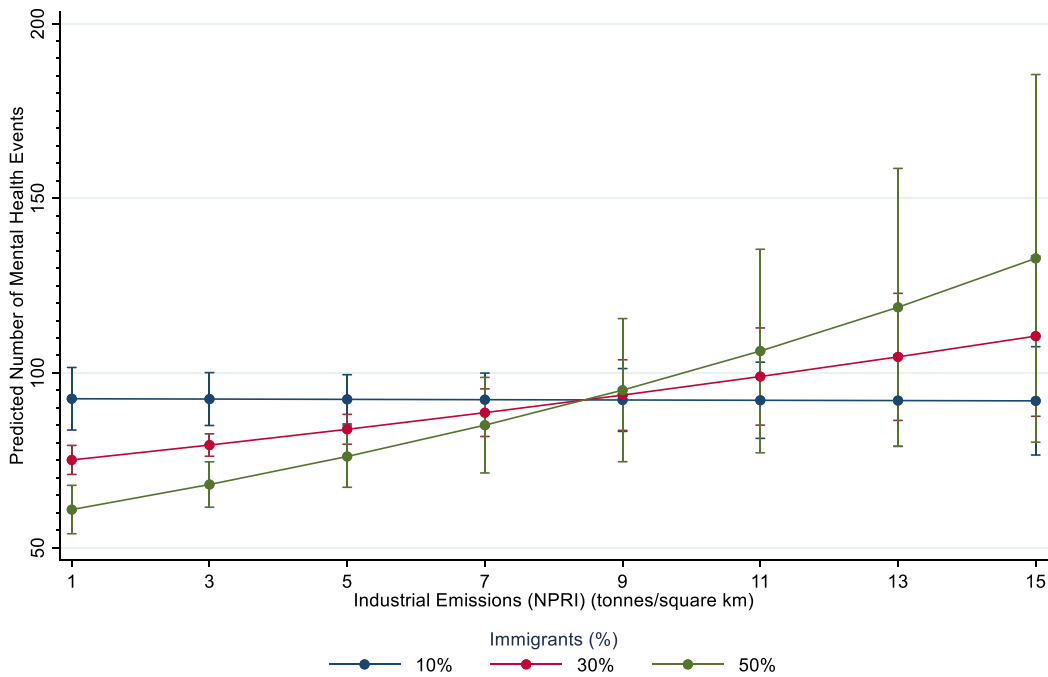
Figure A8.3 Predictive margins with 95% confidence intervals for the effect of a) industrial emissions (tonnes/km^2) at increasing percentages of total immigrants and b) the percentage of total immigrants at increasing industrial emissions (tonnes/km^2) on the predicted number of mental health events in Edmonton, AB (2015-18); model further adjusted for precipitation, average temperature, percentage of older adults, material and social deprivation, greenness (ndvi), seasonality, the number of emergency medical services within 5km, and the number of clinics within 1km.
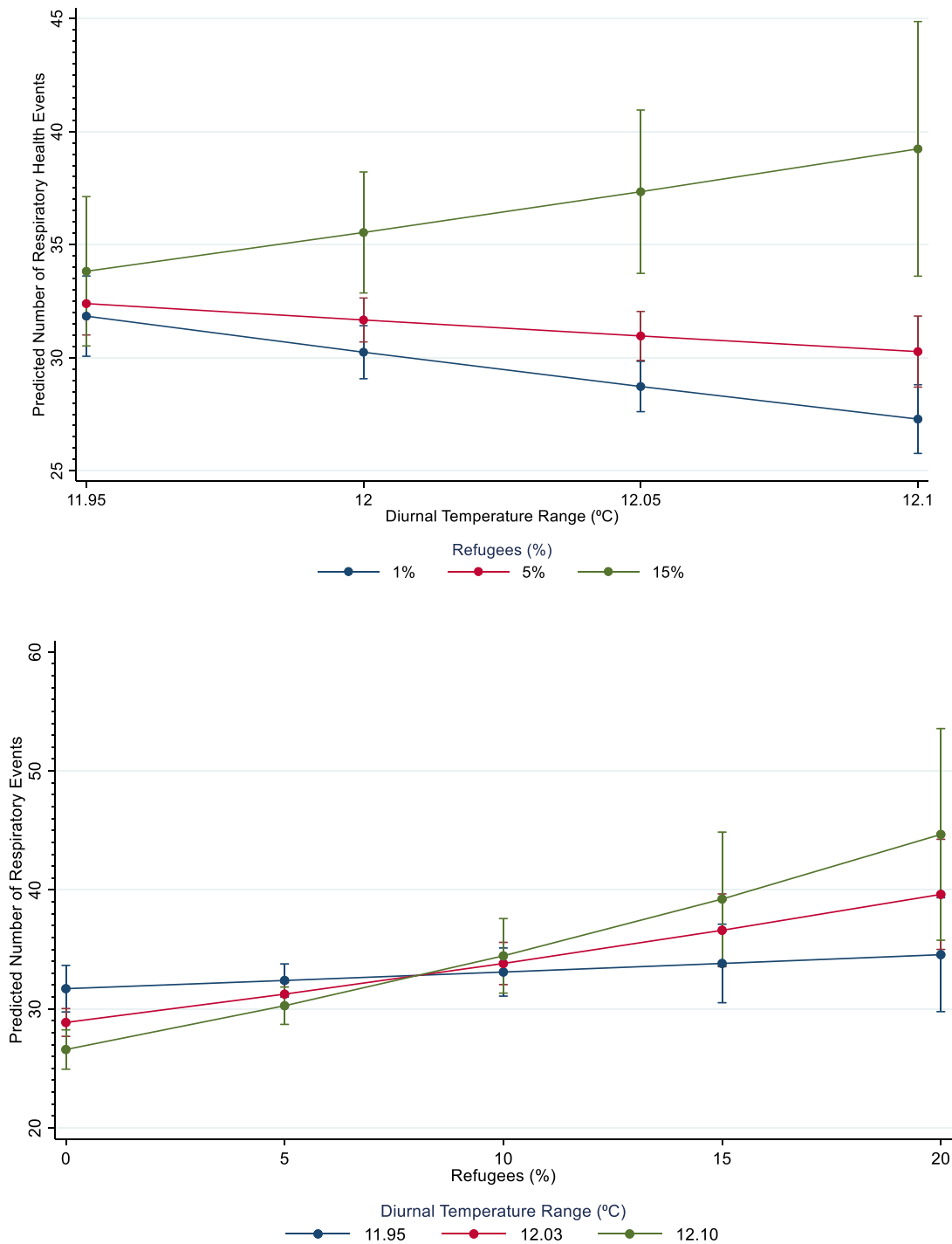
Figure A8.4 Predictive margins with 95% confidence intervals for the effect of a) diurnal temperature range at increasing percentages of refugees and b) the percentage of refugees at increasing diurnal temperature ranges (ºC) on the predicted number of respiratory events in Edmonton, AB (2015-18); model further adjusted for precipitation, percentage of older adults, material and social deprivation, greenness (NDVI), Active Living Environment, seasonality, the number of emergency medical services within 5km, and the number of healthcare facilities and clinics within 1km.