HEALTH VULNERABILITY TO EXTREME HEAT EVENTS IN HAMILTON, ONTARIO

HEALTH VULNERABILITY TO EXTREME HEAT EVENTS IN HAMILTON, ONTARIO

BY JOANN VARICKANICKAL, BES.

A Thesis Submitted to the School of Graduate Studies in Partial Fulfillment of the Requirements for the Degree Master of Arts

McMaster University Master of Arts (2020) Hamilton, Ontario (Geography)

TITLE: Health vulnerability to extreme heat events in Hamilton, Ontario

AUTHOR: Joann Varickanickal, BES (University of Waterloo)

SUPERVISOR: Dr. Bruce Newbold

NUMBER OF PAGES: 70

Abstract

Climate change is expected to affect Canada through extreme heat events (EHEs). Already vulnerable populations, including newcomers and immigrants, will especially be vulnerable to the health impacts associated with EHEs. This population is important to consider for a country as diverse as Canada. With a focus on Hamilton Ontario, this thesis will assess barriers that immigrants and newcomers face with coping to EHEs. Adverse impacts they face will also be discussed. Current formal and informal coping methods will also be highlighted. Quantitative analysis will also be used to explore the relationship between EHEs, air quality (as measured by the Air Quality Health Index (AQHI)), forward sortation areas and hospital admission for heat-related illnesses. The results of this study highlight that unique factors influencing heat health vulnerability among immigrants and newcomers in Hamilton. The benefits of current formal and informal coping mechanisms will also be discussed, as well as areas for improvement. Quantitative analysis also highlights that the AQHI, maximum temperature and a heat event can impact if an individual is admitted to the hospital for a heat-related illness. However, age, gender and most FSAs were not statistically significant. This thesis highlights the importance of considering the immigrant and newcomer population for EHE and general climate change adaptation efforts.

Acknowledgements

Thank you to my supervisor Dr. Bruce Newbold for your consistent support during this entire project.

Table of Contents

Declaration of Academic Achievement

I, Joann Varickanickal, am the primary author and was responsible for the data collection, analysis, and writing of this thesis.

Chapter One

1.1 Research Context

1.1.1 Climate Change in Canada

Climate change has various direct and indirect impacts on human health (Watts et al., 2018). One way is through extreme heat events (EHEs), also known as heatwaves, which are expected to increase in frequency, duration and intensity globally (Wang et al., 2016), and Canada is no exception to this (Government of Canada, 2019). During periods of intense heat, Heat and Humidex advisories in Canada are issued by a federal government agency "when temperatures are expected to reach or exceed 30°C and/or the humidex value is expected to reach or exceed 40 on the Humidex scale of perceived temperature" (Health Canada, 2011). Extreme heat events (EHEs), also known as heat waves, occur when temperatures remain at or above about 32°C for more than three consecutive days (Health Canada, 2011).

EHEs can have a variety of direct and indirect impacts on human health. For example, the 2003 heatwave in France led to about 15,000 heat-related deaths (Mitchell et al., 2019). In 2010, a heatwave in Quebec led to an increase of 33% in the crude death rate (Bustinza et al., 2013). There was also an increase of 4% in admissions to emergency departments (Bustinza et al., 2013). Direct health impacts include heat stroke and heat stroke (Watts et al., 2018). Individuals may also experience indirect health impacts, such as heart failure, through the exacerbation of pre-existing conditions (Watts et al., 2018).

The health impacts associated with EHEs can be further exacerbated by other factors. For example, air quality is also important to consider, as increased temperatures during summer months may affect levels of air pollution, further exacerbating negative health consequences (Harlan & Ruddell, 2011). The urban heat island (UHI) effect, or where urban areas see higher temperatures in comparison to surrounding areas (Tam et al., 2015), can magnify temperatures, increasing the health risks. In Canada, cities across the Windsor-Quebec corridor in the southern part of the country are expected to see an increase in days with average temperatures over 30°C (Wang et al., 2016). For example, in Hamilton, the number of days with average temperatures over 30° is supposed to increase from 37.2 (from 2021-2050) to 63.3 (from 2051-2080) (Climate Atlas, 2019). Currently, in Canada, 70% of the population resides in urban areas making the topic of EHEs in urban areas relevant, as it greatly affects a large part of the population (Wang et al., 2016). Limited vegetation, surfaces with low albedo, heat generating activities, and many other factors all contribute to UHIs (Wang et al., 2016). Populations especially vulnerable to EHEs include the elderly, very young, isolated, individuals with low-income, the homeless and newcomers (Health Canada, 2011).

1.1.2 Immigrants in Canada and Climate Change

Many people immigrate to Canada annually, making it a diverse country. As of 2017, there were over 7,500,000 immigrants in Canada (Statistics Canada, 2019), with more than 280,000 welcomed just that year, and plans to increase the annual number of new immigrants (Government of Canada, 2019). Often, immigrants are healthy when they arrive, meaning they often do not have a disability or chronic illness, as screening processes in Canada favour individuals without serious medical conditions (Newbold, 2005). This leads to the "health immigrant effect", which is when immigrants have high health status when they first arrive. However, this eventually decreases to match the health status of the native-born population (Newbold, 2005). However, refugees are the exception and may have existing health conditions when they immigrate (McKeary & Newbold, 2010).

When developing strategies for climate change adaptation, these should be inclusive to immigrants and newcomers by considering ethnicity, as well as cultural, socioeconomic and other demographic factors (Hansen et al., 2013, 2014). While Health Canada recognizes that newcomers may be especially vulnerable to EHEs (Health Canada, 2011), more work is needed to assess the heat health vulnerabilities in individual cities, especially among newcomers and immigrants. This includes further examining barriers, assessing current initiatives and seeing the impacts of EHEs on heat-related illnesses.

The following three chapters will aim to help fill this gap by focusing on Hamilton, Ontario. Cities such as Hamilton are among common places for immigrants and newcomers to settle. In Hamilton, immigrants make up about a quarter of the population (Hamilton Immigration Partnership Council, 2019). Hamilton also has a history of air pollution (Radisic & Newbold, 2016), providing another reason to make it the study location of this research.

1.2 Thesis Overview

This thesis is organized into five chapters, with the first being this introduction. The second chapter will have a qualitative focus, and will answer the following questions: 1) Are there barriers immigrants in Hamilton face when trying to cope with extreme heat events? If so, what are these barriers?; and 2) Do immigrants in Hamilton experience adverse impacts from extreme heat events? A total of 12 interviews were conducted with service providers in Hamilton, with participants ranging from housing, health, language services and newcomer settlement services. Interviews were semi-structures, and participants were asked about their general knowledge about extreme heat and health, followed by questions about their job and the organization they worked at. Participants were also asked questions specifically related to immigrant health and EHEs. This chapter also applied an intersectional lens. This was done by tying in intersectionality into some of the questions, and also using it to analyze transcripts and frame the results

section. The chapter concludes by highlighting factors that impact heat health vulnerability among newcomers and immigrants in Hamilton, including knowledge gaps among service providers.

The third chapter also applied qualitative methods and used the same methodology from the second chapter. The purpose of this chapter is to explore formal and informal EHE coping measures in Hamilton that are directed at the immigrant population. Using risk perception to frame the work, results highlighted current adaptation efforts, as well as impacts of EHEs on long-term strategies. The chapter provides a needed overview of existing efforts in Hamilton and ways to potentially improve current strategies.

The fourth chapter applied a quantitative approach to: 1) Explore if there is a relationship between EHEs, air quality and hospital admissions in Hamilton; 2) Explore the geography of hospital admissions, represented by forward sortation areas (FSAs), within the city. Hospital data from the Canadian Institute for Health Information (CIHI) was retrieved, specifically the Discharge Abstract Database (DAD), and the National Ambulatory Care Reporting System (NACRS), with a focus on data between May 1st and October 31st of 2016, 2017 and 2018. Both datasets include records of a diagnosis of heat related illnesses, with the DAD dataset including acute care records, and the NACRS dataset including all emergency department visits. They also included the patient's age, sex and FSA. Data from the Air Quality Health Index (AQHI) was also utilized. In Ontario, this index is used to indicate the relationship between air quality in a specific location and human health (Ministry of the Environment, Conservation and Parks, n.d.). Data from the AQHI was also collected for the same period of time. Days with heat events were determined by looking up heat alerts on the City of Hamilton's website. Statistical analysis was used, and the results concluded that AQHI, maximum temperature and the presence of a heat event were all associated with a greater likelihood of admission to hospital. The final chapter provides a conclusion to the thesis. Key findings and contributions are highlighted. Directions for future research are also discussed.

References

Bustinza, R., Lebel, G., Gosselin, P., Bélanger, D., & Chebana, F. (2013). Health impacts of the July 2010 heat wave in Québec, Canada. *BMC Public Health*, *13*(1). https://doi.org/10.1186/1471-2458-13-56

Climate Atlas. (2019). Retrieved from https://climateatlas.ca/map/canada/plus30_2060_85#lat=43.49&lng=-80.73&z=7&city=451

Government of Canada. (2019). *2018 Annual Report to Parliament on Immigration*. Retrieved from https://www.canada.ca/en/immigration-refugees-citizenship/corporate/publications-manuals/annual-report-parliament-immigration-2018/report.html

Government of Canada. (2019). *Canada's Changing Climate Report-Executive Summary*. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR_ExecSumm-EN-040419-FINAL.pdf

Hansen, A., Bi, L., Saniotis, A., & Nitschke, M. (2013). Vulnerability to extreme heat and climate change: Is ethnicity a factor? *Global Health Action*, *6*(1). https://doi.org/10.3402/gha.v6i0.21364

Hansen, A., Nitschke, M., Saniotis, A., Benson, J., Tan, Y., Smyth, V., Wilson, L., Han, G. S., Mwanri, L., & Bi, P. (2014). Extreme heat and cultural and linguistic minorities in Australia: Perceptions of stakeholders. *BMC Public Health*, *14*(1). https://doi.org/10.1186/1471-2458-14-550

Hamilton Immigration Partnership Council (Instituation/Organization). (2019). *A demographic profile of immigrants in Hamilton*.

Harlan, S. L., & Ruddell, D. M. (2011). Climate change and health in cities: Impacts of heat and air pollution and potential co-benefits from mitigation and adaptation. *Current Opinion in Environmental Sustainability*, *3*(3), 126–134. https://doi.org/10.1016/j.cosust.2011.01.001

Health Canada. (2011). *Communicating the health risks of extreme heat events: Toolkit for public health and emergency management officials*.

McKeary, M., & Newbold, B. (2010). Barriers to care: The challenges for Canadian refugees and their health care providers. *Journal of Refugee Studies*, *23*(4), 523–545. https://doi.org/10.1093/jrs/feq038

Ministry of the Environment, Conservation and Parks. (n.d.). *What is the Air Quality Health Index?* Retrieved from http://www.airqualityontario.com/science/aqhi_description.php

Mitchell, D., Kornhuber, K., Huntingford, C., & Uhe, P. (2019). The day the 2003 European heatwave record was broken. *The Lancet Planetary Health*, *3*(7), e290–e292. https://doi.org/10.1016/S2542-5196(19)30106-8

Newbold, K. B. (2005). Self-rated health within the Canadian immigrant population: Risk and the healthy immigrant effect. *Social Science and Medicine*, *60*(6), 1359–1370. https://doi.org/10.1016/j.socscimed.2004.06.048

Radisic, S., & Newbold, K. B. (2016). Factors influencing health care and service providers' and their respective "at risk" populations' adoption of the Air Quality Health Index (AQHI): A qualitative study. *BMC Health Services Research*, *16*(1), 1–11. https://doi.org/10.1186/s12913-016-1355-0

Tam, B. Y., Gough, W. A., & Mohsin, T. (2015). The impact of urbanization and the urban heat island effect on day to day temperature variation. *Urban Climate*, *12*, 1–10. https://doi.org/10.1016/j.uclim.2014.12.004

Wang, Y., Berardi, U., & Akbari, H. (2016). Comparing the effects of urban heat island mitigation strategies for Toronto, Canada. *Energy and Buildings*, *114*, 2–19. https://doi.org/10.1016/j.enbuild.2015.06.046

Watts, N., Amann, M., Ayeb-Karlsson, S., Belesova, K., Bouley, T., Boykoff, M., Byass, P., Cai, W., Campbell-Lendrum, D., Chambers, J., Cox, P. M., Daly, M., Dasandi, N., Davies, M., Depledge, M., Depoux, A., Dominguez-Salas, P., Drummond, P., Ekins, P., … Costello, A. (2018). The Lancet Countdown on health and climate change: from 25 years of inaction to a global transformation for public health. *The Lancet*, *391*(10120), 581–630. https://doi.org/10.1016/S0140-6736(17)32464-9

Chapter 2

2.1 Introduction

Globally, there has been an increase in the intensity, frequency and duration of extreme heat events (Campbell et al., 2018). Every region across the world has seen an increase in vulnerability to extreme heat since 1990 (Watts et al., 2018), and Canada is no exception to this (Paterson et al., 2012). In the last 100 years, surface air temperatures have increased, induced by human actions (Campbell et al., 2018). Average annual temperatures over land have increased by 1.7°C in Canada since 1948 (Government of Canada, 2019). In Canada, Heat and Humidex advisories are issued by Environment and Climate Change Canada "when temperatures are expected to reach or exceed 30°C and/or the humidex value is expected to reach or exceed 40 on the Humidex scale of perceived temperature" (Health Canada, 2011). Extreme heat events (EHEs), also known as heat waves, occur when temperatures remain at or above about 32°C for more than three consecutive days (Health Canada, 2011).

An increase in the likelihood and severity of heat events should be a concern for Canadian communities as high temperatures can cause increased human morbidity and mortality (Watts et al., 2015). Higher temperatures can also contribute to poor air quality, which also impacts human health via stresses on the cardiovascular system (Harlan & Ruddell, 2011). EHEs and days with poor air quality have also been linked to an increase in admissions to health care facilities (Paterson et al., 2014). Vulnerability to extreme heat depends on various factors including age, income, race, level of education, existing illnesses and personal habits related to heat adaptation (Ho et al., 2018). In terms of awareness of heat alerts, the current literature highlights a lack of awareness of the health risks of EHEs among the elderly, socially isolated and other vulnerable individuals (Bassil & Cole, 2010). Likewise, immigrants, and in particular older immigrants or new arrivals with limited English language ability and few social connections, may be a group vulnerable to heat events but may not be directly targeted in educational and outreach efforts given language or other issues. In many cases, however, immigrants may be a forgotten group when it comes to messaging about EHEs from public health units. With climate change expected to result in an increase in the number of extreme events, it is important to consider the barriers that immigrants face when coping with EHEs and their adverse effects, enabling more effective messaging and action from public health.

This study focuses on Hamilton Ontario, a Canadian city located at the western end of Lake Ontario (Figure 1). The annual number of days with temperatures above 30°C is expected to increase from 16.1 (from 1976-2005) to 37.2 (from 2021-2050) to 63.3 (from 2051-2080) (Climate Atlas, 2019). Hamilton's Heat Warning and Information System had three levels of warning until the summer of 2019, when it was reduced to two. As this study focuses on extreme heat events for 2016, 2017, and 2018, three levels of

warning were included. The Heat Advisory is the lowest level and is triggered when there is "one day with a forecasted temperature greater than or to equal 31°C and humidex of 40°C or greater (A. Wilson, personal communication, June 18, 2020)." The Heat Warning is the second level and is triggered when "two or more consecutive days forecasted with daytime highs greater than or equal to 31°C and nighttime lows greater than or equal to 20°C or two or a Humidex of 40°C or greater (City of Hamilton, 2020)." The third level is the Extended Heat Warning, triggered during "three or more consecutive days observed with daytime highs greater than or equal to 31°C and nighttime lows greater than or equal to 20°C or a Humidex of 40°C or greater (City of Hamilton, 2020)." For the first level, cooling centres would open, and free bottled water would be distributed by the Salvation Army (A. Wilson, personal communication, June 18, 2020). Both the second and third levels trigger similar responses, with the city advising against strenuous outdoor activity (City of Hamilton, 2020). In addition, the city makes available a number of cooling sites for residents to cool off in, including recreation centres, libraries, as well as community sites such as Hamilton Urban Core Community Health Centre (City of Hamilton, 2020). Heat warnings are sent out via television, radio, local newspaper and the city's website and social media (City of Hamilton, 2020). Information about reducing the risk of heat-related illnesses is also available in multiple languages (City of Hamilton, 2020).

Framed by intersectionality and focusing on immigrants in Hamilton using qualitative methods, this paper will examine two questions: 1) Are there barriers immigrants in Hamilton face when trying to cope with extreme heat events? If so, what are these barriers?; and 2) Do immigrants in Hamilton experience adverse impacts from extreme heat events?

2.2 Literature Review: The Impacts of EHEs on Immigrant and Newcomer Populations

There is strong evidence that immigrants in Canada can be especially vulnerable to health disparities compared to the rest of the population (McKeary & Newbold, 2010; Newbold, 2005). Various factors contribute to health disparities, including the 'healthy-immigrant effect', adopting unhealthy lifestyle choices such as poor diets, and limited social networks (Newbold, 2005). Furthermore, many refugees are resettled in Canada each year, and research has shown that refugees are especially vulnerable to non-communicable diseases and mental health problems (Langlois et al., 2016; McKeary & Newbold, 2010). Thus, due to their potential for health vulnerabilities, considering the experiences of immigrants during EHEs is important. It is also important to note that the meanings between the terms migrancy, ethnicity and race often varies between geographic regions, and yet they are often used interchangeably (Hansen et al., 2013). Thus, caution must be used when applying studies from one country to another (Hansen et al., 2013).

Studies have looked at how ethnic minorities in general as well as the broader immigrant population may be specifically associated with vulnerability to extreme heat (Hansen et al., 2014; Hansen et al., 2013),

with sociodemographic factors playing a large role in vulnerability. For example, factors such as language barriers and living conditions have contributed to vulnerability among minorities in Australia (Hansen et al., 2014; Hansen et al., 2013). Furthermore, interviews and focus groups conducted with community members and those providing service to or working with culturally diverse groups in Australia concluded that factors such as isolation, cultural norms, low literacy rates and existing health issues can also contribute to extreme heat vulnerability (Hansen et al., 2014). For example, social isolation is especially a problem among asylum seekers who have limited connections in the country they have immigrated to (Hansen et al., 2014). It is especially dangerous when people are confined to their own homes in isolation during warmer weather conditions (Hansen et al., 2014).

Cultural norms will also shape vulnerability and response to heat events. For some, accepting information pamphlets may not be considered a typical avenue for knowledge dissemination, and cultural norms and expectations may also prevent individuals from using swimming pools to cool off during heat waves (Hansen et al., 2014). Cultural norms may also dictate the type of clothing that is worn, some of which may not be suitable for warmer weather (Hansen et al., 2014). Many newcomers as well as older migrants have low-literacy levels, which can be a barrier to accessing information, and oftentimes it can be difficult to translate literature (Hansen et al., 2014). Furthermore, women are especially at risk in some communities. For example, Liberian women having poor literacy rates even in their own language (Hansen et al., 2014). Fluid intake also varies among cultures, as some do not like the taste of water (Hansen et al., 2014). Individuals from certain ethnic groups, such as Middle Eastern men often consume less water than needed (Hansen et al., 2014). Overall, a variety of cultural and sociodemographic factors contribute to heat vulnerability among immigrants.

Socioeconomic status can also influence impacts of extreme heat events on health. For example, refugees or others with low socioeconomic status may not have the financial means to afford to buy or use an air conditioner because of the cost of the unit as well as the added costs to electricity (Hansen et al., 2014). They may also have limited resources to access services that are available to the public with a cost, such as community swimming pools (Hansen et al., 2014). Furthermore, many newcomers are forced to rely on public transportation posing a problem when there is limited public transportation available and for older adults who are forced to leave their homes and use public transportation during heat events (Hansen et al., 2014). Neighborhoods with higher outdoor temperatures were more likely to be occupied by ethnic minorities, and those with lower socioeconomic status (Yardley et al., 2011). Another study in Hamilton mapped population vulnerability to determine which areas would be at greatest risk of the broader impacts of climate (Cheng & Newbold, 2010). The study highlighted that neighborhoods, specifically in downtown Hamilton, with a higher number of low-income immigrants, were more vulnerable to climate change

(Cheng & Newbold, 2010). Thus, socioeconomic status is important to look at when assessing heat vulnerability among immigrants.

Employment is also important to consider. Often immigrants work in positions that are undesirable and require minimal skills (Sterud et al., 2018). Many often settle in jobs that they are overqualified for (Dean &Wilson, 2009). While the literature on health vulnerability to EHEs does not highlight the impact of employment conditions, literature specifically on immigrant employment does (Dean & Wilson, 2009; Sterud et al., 2018). Immigrants in a qualitative study in Canada highlighted hot and poorly ventilated work conditions (Dean & Wilson, 2009). They also highlighted this could have negative health consequences if they worked in these jobs for an extended period of time (Dean & Wilson, 2009).

Those coming from cooler climates may also have trouble acclimating to warmer climates and may not have the necessary knowledge to adapt to hotter weather (Hansen et al., 2014). Many newcomers migrating from one region with warm weather to another also have difficulty adjusting to the weather (Hansen et al., 2014). For example, migrants moving from African countries to Australia are not used to the dry conditions in Australia (Hansen et al., 2014), while high heat and humidity – typical of weather patterns in Southern Ontario, may also pose a challenge. These factors also need to be considered when assessing how periods of warm weather impact immigrant communities.

There are existing research gaps for this topic in Canada, with further research needed to assess the impacts of extreme heat on health, specifically among the immigrant community. With a focus on Hamilton, this work extends our understanding of heat events. Further, we extend the analysis by considering the immigrant population, exploring barriers that may affect their experience to outreach and educational efforts during heat alerts. Adverse impact of periods of hot weather will also be uncovered and discussed. Filling these research gaps would help determine how to include this population in climate change adaptation policies.

2.3 Methods

2.3.1 Study area

With a 2016 population of 536,917, Hamilton's population is projected to grow by 37% by 2041 (Hamilton Immigration Partnership Council, 2019). The city is known for its industrial, education and health care sectors (Agyekum & Newbold, 2016; Wilson et al., 2009). As of 2016, the unemployment rate was 7.4 percent, which was 0.4 percent lower than the provincial rate (Statistics Canada, 2019). Immigration has played an important role in the growth of Hamilton's population in recent years, as two-thirds of the population increase in Hamilton in 2016-2017 was a result of immigration (Hamilton Immigration Partnership Council, 2019). As of 2016, immigrants made up about a quarter of the city's

population, with 130, 365 individuals (Hamilton Immigration Partnership Council, 2019), in addition to 24, 535 refugees (Statistics Canada, 2019). Many newcomers are not fluent in English.

The city of Hamilton is comprised of six communities: Ancaster, Stoney Creek, Dundas, Flamborough, Glanbrook, and Hamilton. The city is divided by the Niagara Escarpment, and the lower, older city has a higher proportion of individuals with lower socioeconomic status, while those in the upper city are typically wealthier (Radisic & Newbold, 2016). While settling across the city, larger shares of immigrants are found in the older, inner city and in the city's east end, including the community of Stoney Creek. The east end is an important location for immigrant settlement, regardless of their year of arrival (Hamilton Immigration Partnership Council, 2019). It not only includes recent immigrants, but compared to the rest of Hamilton, it also has a higher proportion of those who arrived before 2001 (Hamilton Immigration Partnership Council, 2019).

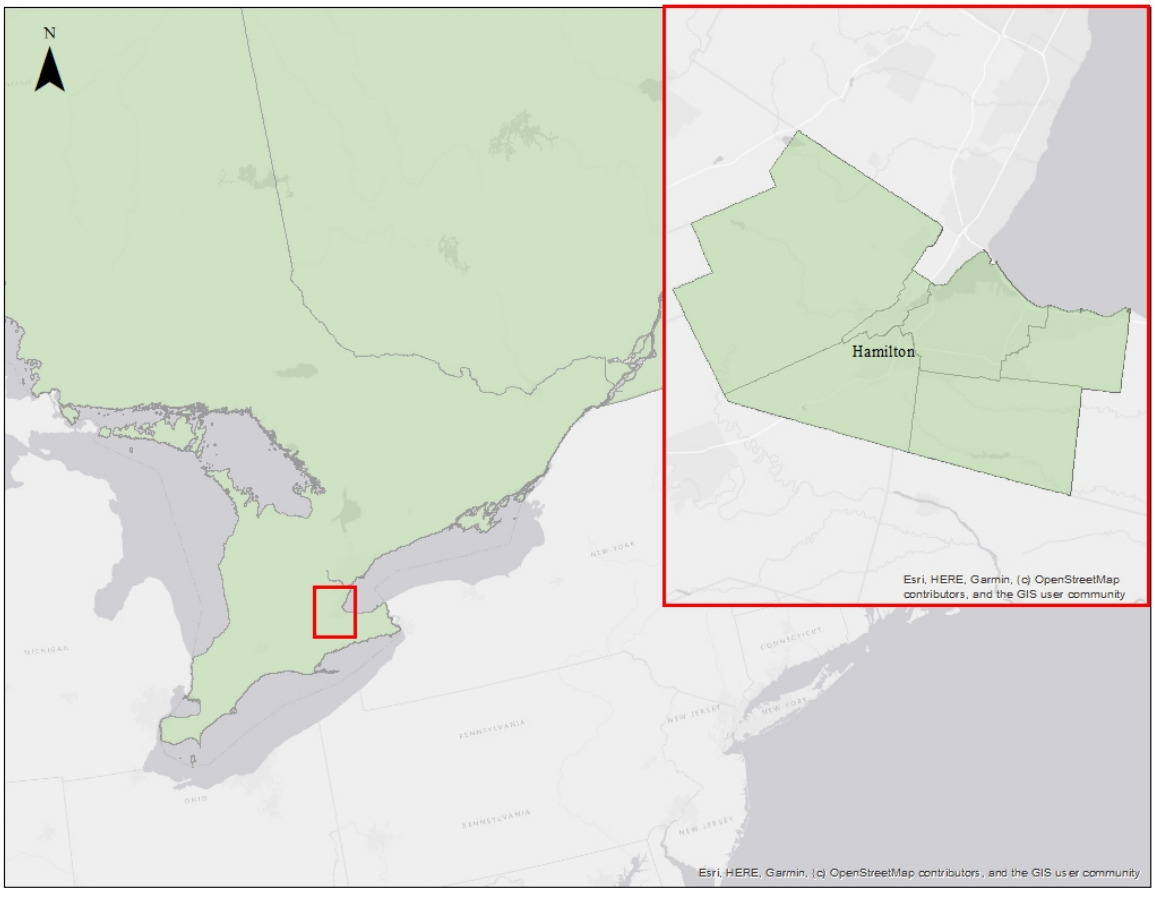

Figure 1: The study site, Hamilton, Ontario (City of Hamilton, 2018; Statistics Canada, 2019).

Approximately 17 percent of Hamilton's population is 65 years and older (Statistics Canada, 2019). In general, the immigrant population is skewed toward older age groups (Hamilton Immigration Partnership

Council, 2019). However, recent arrivals tend to be younger than non-immigrants in Hamilton (Hamilton Immigration Partnership Council, 2019). In Hamilton, individuals ages 25 to 45 make up 25.3 percent of the population, yet individuals ages 25 to 45 made up 45.3 percent of recent immigrants (Hamilton Immigration Partnership Council, 2019; Statistics Canada, 2019). Those aged 45 years and older make up 6.7 percent of all immigrants in Hamilton (Statistics Canada, 2019). Among recent immigrants, there is also a higher proportion of females compared to males (Hamilton Immigration Partnership Council, 2019). 83.8 percent of Hamiltonians report English as the language spoken most often at home (Statistics Canada, 2019).

2.3.2 Recruitment

Service providers in Hamilton were recruited to help answer the research questions for this study. Service providers included individuals working with government and non-government organizations. Interviews were conducted with individuals working in housing (4), language services (1), health (5), and newcomer settlement (2) in Hamilton. By focusing on these individuals, we accessed trusted resources knowledgeable about heat, housing, and public health issues. The University Research Ethics Board at the author's institution approved this research and all methods and procedures.

Participants were recruited through two methods. Convenience sampling was used with providers recruited through personal connections of the investigators by telephone and email. Snowball sampling was also used with participants providing recommendations for other service providers to speak with. Interviews took place on a rolling basis from July to December 2019. In total, there were 12 interviews conducted. Respondents were given anonymity, with quotes (numbered to identify the respondent) presented in the results section below.

2.3.3 Conducting interviews

In total, 11 interviews were conducted in person at the place of employment of the service provider and one interview was conducted over the phone. Interviews were audio-recorded, with supplementary handwritten notes taken to ensure that any additional information (e.g. about body language or questions or concerns from the participants) were noted. Each interview took approximately 30 minutes. Semi-structured interviews were conducted one-on-one, with the exception of one interview conducted with two people, and another with four people. Interview guides were also utilized. Participants were asked about their general knowledge of heat events and the impacts of extreme heat (see Appendix A). These were followed by questions about their role at the organization they worked at. Participants were also asked more specific questions related to extreme heat and immigrants. Questions tying in intersectionality were included, asking participants about the potential impact of age, gender and immigration on vulnerability and coping mechanisms during heat events.

2.3.4 Analysis

After transcribing interviews, deductive coding was used to develop a list of potential themes based on the existing literature. In the first cycle of coding, interviews were analyzed and a code (keyword or phrase) was applied to summarize a key message or theme. Codes were based on existing themes, and new ones that emerged were based on inductive reasoning. Two transcripts were shared with the principal investigator for review to ensure appropriate and consistent coding. This also helped to enforce credibility and dependability, reducing the risk of idiosyncrasies in the analysis and interpretation of the transcripts (Baxter & Eyles, 1997). A second cycle of coding was then completed. Codes were cleaned, and similar codes were joined together/re-named to ensure consistency across the same themes. Codes were grouped together under sub-themes and general themes, and then again under another broader category, if necessary. Supporting quotes were then added to each sub-theme.

Intersectionality will be used to frame this research (Crenshaw, 1989). Crenshaw explored how the intersectionality of race and gender impacted African American women, noting that they were often left out of research and politics (Liu, 2019) and the feminist movement up until that time, as it was not inclusive to their experience (Shields, 2008). It is used as both a theory (Choo & Ferree, 2010), and a method, forcing researchers to take an analytical approach (Kaushik & Walsh, 2018). Intersectionality highlights that human lives are shaped by interactions between a variety of factors such as gender, race, religion, disability/ability and age (Hankivsky, 2014). These elements are considered to be social locations (Hankivsky, 2014). As a result, human experiences, perceptions, and general day-to-day lives are impacted by a variety of elements, not just one. Furthermore, these social locations take place within power structures in society, such as policies and religious institutions (Hankivsky, 2014). These interactions among various factors and within systems of power lead to inequality (Hankivsky, 2014). Thus, it is not one element of social location that leads to privilege and oppression, but a complex interaction of factors within power structures (Hankivsky, 2014). Intersectionality is a useful theory for this study as assessing the health vulnerability among immigrant populations requires that multiple elements are considered to determine which factors actually influence the vulnerability of this group during extreme heat events. Intersectionality has been used to frame research about immigrants in Canada, focusing on their job opportunities (Liu, 2019) and settlement and integration (Kaushik & Walsh, 2018). It is not enough to assume that just because an individual has immigrated to Canada that they are or are not vulnerable to extreme heat events. Their immigration status, age, gender and a variety of other factors should be considered.

Applying intersectionality is done by connecting systems in society to individual experiences (Hankivsky, 2014). Although applying intersectionality can be a complex task, researchers have highlighted that it can be simplified by considering specific groups with existing intersections of social locations (Windsong, 2018). Another approach is to focus on including groups that have traditionally been

marginalized from academic research (Windsong, 2018). Research completed by Windsong (2018), highlighted that an intersectionality approach can be taken in interviews by including questions that ask about different social locations, such as race and gender. Answers to these questions provided rich information (Windsong, 2018). For this study, intersectionality theory will frame the project and also guide the development of interview questions. This was done by asking participants general questions about immigrant vulnerability to heat events, as well as questions about specific factors that, according to existing literature, could affect their vulnerability.

2.4 Results

Existing research highlights that factors including age, gender and isolation contribute to health vulnerability during EHEs (Bi et al., 2011; Hansen et al., 2011; Knowlton et al., 2009; Lin et al., 2009; O'Lenick et al., 2019; Yardley et al., 2011; Zhang et al., 2013). While these themes were also evident in the transcripts, three broad themes are focused on in this paper: the intersecting roles of language, culture, gender and religion, the digital divide and socioeconomic status, as well as knowledge gaps. Together, these themes expand current findings by highlighting unique vulnerabilities newcomer and immigrant communities may experience. That is, factors such as age and gender that are commonly associated with increased vulnerability to heat events take on more nuanced impacts within the immigrant population. Building on existing literature, this study highlights unique vulnerabilities immigrants may face with current cultural and technological factors.

2.4.1 Vulnerability Factors

Lost in Translation: Language, Culture, Gender and Religion as Intersecting Factors

Beyond age, gender, and social isolation, a variety of vulnerability factors unique to immigrants were highlighted by service providers, with these unique factors complicating the impact or role of more traditional vulnerability factors such as gender (i.e., Zhang et al., 2013), with the potential for intersectionality revealed in the transcripts. Women may be more vulnerable to EHEs if they are living on their own, as they may be afraid of voicing concerns. However, men may be at a greater risk of heat-related illnesses due to exposure during recreational and occupational activities (Pillai et al., 2014). While overlapping with cultural factors, gender also affects how an individual receives and applies information given differences in responsibilities and how information is received and applied. Gender also often influences responsibilities and roles amongst individuals, households, and communities.

While gender affects awareness of and vulnerability to EHEs, it can also take on different dimensions within the immigrant population. One participant, who works in newcomer settlement, highlighted that men may have greater exposure to information:

"…I'm not sure. The research shows that men are acquiring language skills faster than women sometimes because it's more a priority, because often they're the breadwinner. Women are more likely to be childminding and doing those things the first year after settlement and not really focusing on themselves. So, they may be learning [the] language at a later point. So, in that sense, it might be harder to reach them, or have them receive messages…Maybe people, some people, cultures might have different expectations that are more gender based than others."-5

While others highlighted that females may have greater exposure to information:

"Well, in our organization, we have more females than males. Okay. So, in our organization females get information through us more than the males do. Because the men are usually working, and the ladies are going to school. Our ratio would be like 25% male and 25% females, okay. And they have young children and daycare so in our families that come to our school, the females will hear information from us."-1

Gender may also influence whether information is applied:

"All I can tell you is from my own personal research…we looked at differences in males versus females, being aware…and we found that males were more aware…but what we found was that, although they were more aware that the tool exists, and they were less likely to use it or apply it. Whereas if women were aware, they were more likely to apply it, right."-12

Gender norms within cultures may also affect dress code and responsibilities, which may then influence vulnerability to EHEs. For example, women often have different expectations in terms of dress code. Even in warmer temperatures, many will still have to follow cultural dress codes and wear head coverings or full dresses [due to cultural and/or religious customs]. This may also influence their vulnerability during EHEs (Hansen, Nitschke, Saniotis, et al., 2014).

"For the women, the way their dressed, what their practices are, how they cool down…some women wear full dresses or coverings for their head, and so you know I think that that could be hot. Also, that they're cooking, and that they're expected to cook. I'm making a generalization, but we know that kind of thing, they're on their feet more, the work never ends. Right? So, I think in that sense you might have some gender effects."-8

The quotes above highlight that gender effects on heat health vulnerability can be complex, as it is heavily influenced by culture, which is intertwined with employment and education. These interact within power structures in society, creating different levels of opportunities and setbacks. Beyond gender, a series of other sociodemographic characteristics create vulnerability to EHEs within the immigrant community. In particular, language as a barrier to accessing general information and services, as well as a potential barrier to information about EHEs was mentioned by many participants. This aligns with current research which highlights that an individual's limited fluency in a country's official language impedes the ability to understand weather reports, and information about mitigation measures to reduce the impacts of hot weather (Hansen et al., 2013, 2014), echoed by participants:

"…They don't know what they don't know, because how would they know to go to the website and find out about the free swims or find out about an extreme heat event. If the news media is saying that there's

an extreme heat alert, and it's in English, what if they don't listen to that radio station, right?...But I think if it's not in their language, and they don't know what they don't know. Right?"-8

"But if they are accessing services out in the community and they don't have an interpreter yes, they will have a problem."-11

Participants also highlighted that children in newcomer families play an important role in reducing language barriers, acting as translators for their parents. Research focusing on the general health of newcomers in Canada also highlights this, emphasizing this as a trend among the refugee population (McKeary & Newbold, 2010). This is important to consider, as because of their young age, information must be provided in a way that they can understand.

"What we do find is children playing an increasing role because of language barriers…Because of the translations you just, you know, it's difficult to provide information, various languages, and if you don't have the internal capacity to do that…So you wind up relying a lot on children as translators, and all of our units are family units. Okay, so almost all the units have children…So conveying information sometimes has to be when you have no idea what's going to parents. But it also has to be conveyed or provided in a way that the child can understand."-2

Identities are dynamic (Shields, 2008), and children may experience certain pressures at a young age. This may also intersect with elements related to culture and gender. There may be greater pressures on older children to provide leadership, or female children may be expected to take on certain tasks such as tutoring parents and siblings (Orellana et al., 2003). Changes in the intergenerational dynamic also take place as children take on roles of translating and are present in serious conversations, forcing parents to depend on children (Orellana et al., 2003), something they may not have dealt with before immigrating. All of this puts children in a unique role, and also sheds light on power structures, as language barriers may be especially prominent when immigrants and newcomers have to deal with institutional and cultural differences that are new to them (Orellana et al., 2003).

Cultural and religious factors are also important to consider when assessing immigrant and newcomer vulnerability to EHEs. These factors can affect how they experience and cope with EHEs. For example, one participant, who works in newcomer settlement, commented that:

"But sometimes in other country, they shut down in the middle of the day when it's hot, right? Everyone goes home for lunch. And there's a quiet time, that kind of thing. We don't have that here…it's challenging…If you are coming from a country where most people are observing Ramadan, the whole rhythm of society changes during Ramadan, but here it doesn't." -5

It is important to consider religious customs during EHEs if it means that practicing individuals must fast from eating and drinking, as this may increase their vulnerability to heat-related illnesses. If Ramadan aligns with an EHE, this could be a problem (Hansen et al., 2014). There may also be a lack of knowledge on

skills needed to cope with EHEs, potentially increasing vulnerability; this may overlap with cultural factors. A participant from the health sector noted that:

"The other aspect of culture is that we have these open swims or free swims…it's great to have this, but they might be fearful, they may not know how to swim, they may not have the appropriate wear. So just because we have it available doesn't mean they're going to use it."-8

It is important to ensure that the target population for mitigation efforts have the necessary skills to utilize resources. Similar research highlighted that not knowing how to swim may also pose a problem among newcomers who want to stay cool during periods of hot weather (Hansen et al., 2014). Although resources, such as swimming pools, may be available for free, certain skills are required for utilization. This emphasizes how resource use is dependent on various intersecting factors such as income and culture.

The power-dynamics between landlords and tenants is also important to consider among newcomers and immigrants because it may influence their willingness to ask and receive help from those in an authoritative position. Landlords, and others with power, can take advantage of tenants because they are already in vulnerable situations, making tenants reluctant or unable to seek help from them (Grineski & Hernández, 2010).

"But also, depending on your place of origin, and depending where you've come from like lots of people have come from abuse and war torn countries, etc., so the landlords like 'Big Brother', and it's not always, you know, that hasn't been necessarily good news story in their place or origin. So you know, sometime if you see letters from a landlord, you don't read them…A lot of our tenants are newcomers. And it's amazing how you're received, you know it's law that we go in every year and check. It's about the health and safety, it's about fire safety and so on and so forth. But the reaction from people, really there's a huge spectrum of how they react. And I think if they're newcomers, a lot of it could depend on what they have experience in their home countries."-9

This highlights a need to build trust with those who have some level of authority. In this case, tenants should be able to trust their landlords. Social locations, such as immigration status and their cultural experiences from their country of origin, interest and interact to influence their interactions with authoritative figures in Hamilton. These social locations influence how they may experience power structures, social locations interaction leading to oppression and privilege at various levels among various individuals depending on their social locations. Landlords play an important role in influencing indoor environmental conditions (Grineski & Hernández, 2010), and it is important that the experiences immigrants and newcomers have do not hinder their ability to trust their landlords in Hamilton. However, this can only change over time as trust between both parties and agency among the tenant is built. Perceptions of information providers, such as landlords, are in important, as if tenants do not have a positive relationship with them, they may not be able to access necessary information or help.

Overall, health vulnerability to extreme heat is influenced by intersecting factors. Participants note the importance of considering language, culture, religion, and gender when looking at health vulnerability to heat events, specifically among immigrant and newcomer communities. Each of these factors can influence an individual's risk at varying levels; however, they are all closely intertwined and cannot be assessed independently. This is important to consider moving forward, as heat mitigation and adaptation efforts cannot consider one factor, for example gender, without considering other factors, such as culture and religion.

The Digital Divide and Socioeconomic Status

Although age on its own is a well-known factor influencing vulnerability to EHEs, age is also reflected in the use and uptake of technology, meaning that older immigrant adults in low-income situations may experience barriers to the use of technology (Hansen et al., 2014). This may create an additional level of vulnerability if they have limited access and the skills needed to use technology. As one participant noted:

"So, the young, middle aged people are more tech savvy. They have cell phones, access to internet or they're used to using the technology, which is the main way of getting messages, nowadays. So, the elderly are limited because they don't have those skills sometimes."-1

Amongst immigrants, limited access to technology due to cost or language barriers limits access to mitigation strategies. Lack of access and use is problematic given that social media, websites, and other technological resources are increasingly utilized to relay information and mitigate the risk of EHEs. For immigrants, however, where the digital divide is highlighted (Guttman et al., 2018; Torralba, 2015), and magnified amongst older immigrants (Hansen et al., 2014), low SES may limit access to technology and resources, and therefore information about EHEs. A participant from the housing sector commented that:

"…There isn't a significant penetration of internet use within buildings. So, which would limit the resources, information resources that our residents have access to…maybe they are relying on data on their phones…actual internet connections, we know is quite low here…so it would be if they get internet themselves."-7

Intersecting with age, lower socioeconomic status complicates access to technology, reinforcing the digital divide and access to information. (Guttman et al., 2018; Torralba, 2015). Reducing this digital divide among immigrants is important as it allows individuals to connect with formal institutions in the community in a way that they may not have previously been able to (Torralba, 2015), highlighting the importance of digital communication during EHEs. Similar research has also noted the impact of SES on accessing phones or televisions (Hansen et al., 2014). Add more about intersectionality and power structures.

Lower socioeconomic status does not just limit access to technology and may prevent individuals from accessing air conditioning units. More specifically, considering the immigrant status of the individual is also important when looking at socioeconomic status.

"I think if you're looking at status, permanent residents that come, landed immigrants, they would have more means and more money so hopefully they would know a little bit more about getting a fan or an air-conditioning, and your government assisted refugees would have supports around them the first year…so hopefully they're doing their job in teaching them or getting fans for them or whatever. Where you might see something is more with the refugee claimants, that might have trouble if they're not hooked up with settlement services or other supports, that don't know how to deal with heat, and even about the free swims or getting fans or anything like that."-8

Socioeconomic status extends beyond access to technology and affects the ability to purchase other household goods including air-conditioners. This also aligns with similar research that noted the potential increase in risk during EHEs among those who are refugees (Hansen et al., 2013, 2014). Participants also noted that cost may also influence ownership and utilization of an air conditioner, which also aligns with current research (Hansen et al., 2011; Zhang et al., 2013). Once again, this highlights the complex nature of health vulnerability to EHEs. Intersecting factors of immigration status and income intertwine, affecting individual levels of oppression. Refugees, who are already vulnerable populations, may continue to face poor health outcomes because of limited financial resources and social networks. Related to this is housing. Depending on the type, housing may also influence vulnerability to EHEs.

"But the other reality… there have been lots of studies done on heat in high-rises. So, as it cools outside for most people in the evening, your house will cool down, but it in high-rises, it just increases. And it's hotter inside than it is outside."-9

If individuals are already unable to afford an air conditioner and they live in a high-rise apartment, this may increase their vulnerability to EHEs. The physical environment of an individual's neighbourhood, which is partially reflective of socioeconomic status, is also important to consider (Bélanger et al., 2016), with lower income neighborhoods often having less green space than more affluent ones. A participant in the health sector noted that:

"…Depending on where they live, too, so we're also looking at that, you know, are there particular hotspots in the city? So depending on, for example, the green space, is there a lot of green space? And we know that green space has that natural cooling ability. "-12

Having green space in neighbourhoods, or at least easy access to green spaces, has been identified in the literature as an important natural resource during heat events, providing relief during EHEs (Ngom et al., 2016). However, green spaces may benefit individuals with a lower socioeconomic status more than those with a high socioeconomic status (Ruijsbroek et al., 2017). Research highlights that ethnic minorities, and other vulnerable populations such as the financially disadvantaged, often live in warmer neighbourhoods that have older homes, unsuitable for air-conditioners (Hansen et al., 2013; Hansen et al., 2014). This again emphasizes that income, age and immigrant status intersect to impact individual health vulnerability to heat in various ways and at various times throughout one's life. Interacting within societal power structures,

these social locations influence levels of oppression and privilege and individual experiences, with each social location influencing each person in a different way.

Knowledge gaps among service providers

It is often assumed that immigrants lack knowledge of EHEs and what to do during heat events. As one participant from the health sector noted,

"Generally, they have to be given the information because they don't know, because of where they are coming from, they don't know how to ask or what to ask. They don't know what is there for them, that has to be out in the open, and they go on from there and let their peers know about these services, so the program broadens from there on. This core group will take the message from the school, and will tell their peers, their friends, people in their building and it goes from there."-8

However, it is also important to highlight that service providers – at least amongst those interviewed for this project - noted they were relatively uninformed about extreme heat in general and did not have enough knowledge or qualifications to provide information about risk reduction strategies. If this is indeed the case, their information may not be accurate or reflect best practices:

"I think lack of knowledge is another potential barrier…None of us had put our minds to it, hadn't really thought about this as an upcoming thing we should plan for it. And so, we haven't thought about it. I think a general knowledge for the residents as well that in these kinds of temperatures and prolonged periods of time, stay hydrated, what are the signs of heatstroke, that kind of thing"-7

"I mean, I don't know where we could direct them if that…I don't know…We can suggest like shower. You know, find another fan like, general things that we know. Because we're obviously not qualified to give them advice…"-1

A lack of knowledge about this issue among service providers reveals their inability to provide help if needed. This is important to consider moving forward for heat emergency planning. Service providers who work with vulnerable populations should be equipped with the knowledge to help those they work with. Increasing knowledge and awareness about the urgency of the topic may influence perceived risks among service providers, potentially prompting mitigation and adaptation strategies for EHEs.

Although it is recognized that older adults and individuals living alone are at risk of poor health outcomes during EHEs, the immigrant and newcomer populations did not appear as a priority issue, despite the potential difficulties of reaching this group. They also highlighted that they are unaware of all the barriers newcomers and immigrants may have to health education and services available during heat events.

"So, we haven't looked at directly doing some research with the immigrant population and asking them about their barriers…We do identify that, yes, perhaps language barriers may exist. But in terms of any other potential barriers, they haven't been identified yet."-12

There should be a basic understanding among service providers that vulnerability to heat events may exist for a variety of reasons. Varying in levels of privilege and oppression, social groups are not homogenous

(Kaushik & Walsh, 2018). Ethnicity and status as a visible minority should be considered as they may contribute to vulnerability among immigrants in Canada and may not have been vulnerability factors in their country of origin, emphasizing that vulnerability can change over time and space (Hankivsky, 2014). These should be considered in addition to socioeconomic status, gender, and other factors. This may help to expand heat mitigation and adaptation methods to consider the needs of newcomers and immigrants. Strategies can also be incorporated into existing programs. Reaching the goals and objectives of primary programs of organizations may have co-benefits to reducing vulnerability to EHEs. Service providers can also work to have a better understanding of social locations and how they interact within power structures, helping to reduce heat health risks among immigrant and newcomer communities.

2.5 Discussion and Conclusion

This paper answered two questions: 1) Are there barriers immigrants in Hamilton face when trying to cope with extreme heat events? If so, what are these barriers?; and 2) Do immigrants in Hamilton experience adverse impacts from extreme heat events?

Applying an intersectionality approach, this study highlighted several factors that may increase immigrant and newcomer vulnerability to EHEs in Hamilton. Participants stressed that age, language, culture, religion, gender, technological literacy, and socioeconomic status can all contribute to vulnerability to EHEs among the immigrant community in Hamilton. Limited knowledge among service providers also inhibits information transfer and reduces their ability to effectively help vulnerable populations during EHEs. The discussion around these factors answered both research questions presented at the beginning of this paper. Answering these questions provides an overview of how immigrant communities are impacted by EHEs in Hamilton and provides an idea of where there are potential gaps in services and direction for future work.

The results indicate it is important to continue to consider how language as well as culture and religion may influence the utilization of resources available to reduce risks associated with heat alerts and EHEs, echoing existing research (Hansen et al., 2014). However, this study was unique in that it shed light on factors related to the use of technology in mitigating the impacts of heat alerts and EHEs in Hamilton. Moving forward in research and educational outreach efforts, this will continue to be important. This includes ensuring that individuals have access to the internet, as well as the knowledge and skills needed to know where to find information about heat alerts. It also includes ensuring that resources, in terms of language and literacy skills, are accessible and culturally relevant. More effort also needs to be made to understand the impacts of limited access and use of technology among the immigrant and newcomer community, and how social media, websites and other technological resources can be utilized to reduce their risks to EHEs. Considering gender is important for future work as it may be important to focus future

communication efforts towards either men or women. It is important to consider how each may be receiving information and unique vulnerabilities that way the information can be developed/put together and disseminated in a way that is useful for the most vulnerable populations. Results also indicated the importance of the natural and built environment, both of which are crucial to consider for heat mitigation and adaption and are impacted by socioeconomic status. The presence of green spaces have multiple positive impacts, as they can reduce temperatures (Ngom et al., 2016), and provides a space for people to congregate, increasing social cohesion and a sense of community (Ruijsbroek et al., 2017). Considering the built environment is also important. Efforts should be made to increase the use of smarter technologies and improve the overall design of houses to reduce the need for air conditioners and the impacts of heat events (Hansen et al., 2014). This is a complex issue, as the policies of landlords may also have to be considered before changes are made to the house or apartment. This highlights the importance of financial autonomy in being able to not only afford fans and air conditioners, but also an individual having the agency to make changes to their home as they see fit (Hansen et al., 2014). Finally, this study concluded with a brief discussion about the need for service to be provided with educational materials related to EHE impacts and adaptation strategies so that they may better serve their communities.

There were several limitations to this study. Our focus on service providers also meant we did not hear about the experiences of newcomers directly. Furthermore, using Participatory Action Research methods for future research projects related to EHEs and climate change is also important. This could help to ensure the research is relevant to those it is supposed to benefit the most. There may have also been personal biases from the researcher while interpreting results. For example, having to reflect on a consistent basis and ensure immigrants were not categorized as a homogenous group and victims. Furthermore, intersectionality was used to frame a few questions in the interview guide and the analysis, but not the research questions. This study also does not discuss other factors such as disability and sexual orientation, which would provide a deeper intersectionality approach. As this study focused on Hamilton, broader results would have to be applied to other cities with caution, as their own unique vulnerabilities would have to be considered.

Overall, intersecting factors can influence heat health vulnerability among. It is important to note, however, that privilege or oppression, based on these factors, can change throughout an individual's life (Kaushik & Walsh, 2018). Furthermore, it is important to avoid an additive approach, highlighting that an increase in each of the factors does not necessarily equate to an increase of inequality (Bowleg, 2008). This is important to consider moving forward. A variety of strategies for heat mitigation and adaptation should be considered, ensuring people who experience privilege and oppression in different ways may avoid risks associated with heat events. As Canada is home to many immigrants, it is important to consider their health

vulnerabilities that may arise or be exacerbated with a changing environment. Moving forward, there are several ways this topic can be further explored. Researchers and service providers could look at the impacts of EHEs on immigrant and newcomer communities in other Canadian cities. Future work could also focus on immigrants and newcomers with disabilities to expand an intersectional approach. Overall, expanding this research to include other geographic regions and specific groups of marginalized populations may help to reduce the health impacts of EHEs.

References

Agyekum, B., & Newbold, K. B. (2016). Sense of Place and Mental Wellness of Visible Minority Immigrants in Hamilton, Ontario: Revelations from Key Informants. *Canadian Ethnic Studies*, *48*(1), 101–122. https://doi.org/10.1353/ces.2016.0001

Bassil, K. L., & Cole, D. C. (2010). Effectiveness of public health interventions in reducing morbidity and mortality during heat episodes: A structured review. *International Journal of Environmental Research and Public Health*, *7*(3), 991–1001. https://doi.org/10.3390/ijerph7030991

Baxter, J., & Eyles, J. (1997). Evaluating qualitative research in social geography: establishing "rigour" in interview analysis. *Transactions of the Institute of British Geographers*, *22*(4), 505–525. https://doi.org/10.1111/j.0020-2754.1997.00505.x

Bélanger, D., Abdous, B., Valois, P., Gosselin, P., & Sidi, E. A. L. (2016). A multilevel analysis to explain self-reported adverse health effects and adaptation to urban heat: A cross-sectional survey in the deprived areas of 9 Canadian cities Environmental health. *BMC Public Health*, *16*(1), 1–11. https://doi.org/10.1186/s12889-016-2749-y

Bi, P., Williams, S., Loughnan, M., Lloyd, G., Hansen, A., Kjellstrom, T., Dear, K., & Saniotis, A. (2011). The effects of extreme heat on human mortality and morbidity in Australia: Implications for public health. *Asia-Pacific Journal of Public Health*, *23*(2 SUPPL.). https://doi.org/10.1177/1010539510391644

Bowleg, L. (2008). When Black + lesbian + woman ≠ Black lesbian woman: The methodological challenges of qualitative and quantitative intersectionality research. *Sex Roles*, *59*(5–6), 312–325. https://doi.org/10.1007/s11199-008-9400-z

Campbell, S., Remenyi, T. A., White, C. J., & Johnston, F. H. (2018). Heatwave and health impact research: A global review. *Health and Place*, *53*(August), 210–218. https://doi.org/10.1016/j.healthplace.2018.08.017

Choo, H. Y., & Ferree, M. M. (2010). Practicing Intersectionality in Sociological Research: A Critical Analysis of Inclusions, Interactions, and Institutions in the Study of Inequalities. *Sociological Theory*, *28*(2), 129–149. https://doi.org/10.1111/j.1467-9558.2010.01370.x

Cheng, J & Newbold B. (2010). Mapping vulnerability to climate change and variability in Hamilton, Ontario using geographical information systems.

City of Hamilton. (2018). *Community Boundaries* . Retrieved from https://open.hamilton.ca/datasets/fdfe2c5081c5459f8aae7f1861a24b15_17

City of Hamilton. (2020, July). *Heat Warnings & Heat Relates Illness*. Retrieved from https://www.hamilton.ca/public-health/health-topics/heat-warnings-heat-related-illness

Climate Atlas. (2019). Retrieved from https://climateatlas.ca/map/canada/plus30_2060_85#lat=43.49&lng=-80.73&z=7&city=451

Crenshaw, K. (1989). Demarginalizing the intersection of race and sex: A black feminist critique of antidiscrimintation doctrine, feminist theory and antiracist politics. In *Feminist Theory and Antiracist Politics. University of Chicago Legal Forum:* (Vol. 1989, Issue 1). https://doi.org/10.4324/9781315631011-38

Dean, J. A., & Wilson, K. (2009). 'Education? It is irrelevant to my job now. It makes me very depressed ': Exploring the health impacts of under/unemployment among highly skilled recent immigrants in Canada. *Ethnicity and Health*, *14*(2), 185–204. https://doi.org/10.1080/13557850802227049

Government of Canada. (2019). *Canada's Changing Climate Report-Executive Summary*. https://www.nrcan.gc.ca/sites/www.nrcan.gc.ca/files/energy/Climate-change/pdf/CCCR_ExecSumm-EN-040419-FINAL.pdf

Grineski, S. E., & Hernández, A. A. (2010). Landlords, fear, and children's respiratory health: An untold story of environmental injustice in the central city. *Local Environment*, *15*(3), 199–216. https://doi.org/10.1080/13549830903575562

Guttman, N., Lev, E., Segev, E., Ayecheh, S., Ziv, L., Gadamo, F., Dayan, N., & Yavetz, G. (2018). "I never thought I could get health information from the Internet!": Unexpected uses of an Internet website designed to enable Ethiopian immigrants with low/no literacy skills to browse health information. *New Media and Society*, *20*(7), 2272–2295. https://doi.org/10.1177/1461444817712937

Hamilton Immigration Partnership Council (Instituation/Organization). (2019). *A demographic profile of immigrants in Hamilton*.

Hankivsky, O. (2014). *Intersectionality 101*. http://vawforum-cwr.ca/sites/default/files/attachments/intersectionallity_101.pdf

Hansen, A., Bi, L., Saniotis, A., & Nitschke, M. (2013). Vulnerability to extreme heat and climate change: Is ethnicity a factor? *Global Health Action*, *6*(1). https://doi.org/10.3402/gha.v6i0.21364

Hansen, A., Bi, P., Nitschke, M., Pisaniello, D., Newbury, J., & Kitson, A. (2011). Perceptions of heat-susceptibility in older persons: Barriers to adaptation. *International Journal of Environmental Research and Public Health*, *8*(12), 4714–4728. https://doi.org/10.3390/ijerph8124714

Hansen, A., Nitschke, M., Saniotis, A., Benson, J., Tan, Y., Smyth, V., Wilson, L., Han, G. S., Mwanri, L., & Bi, P. (2014). Extreme heat and cultural and linguistic minorities in Australia: Perceptions of stakeholders. *BMC Public Health*, *14*(1). https://doi.org/10.1186/1471-2458-14-550

Harlan, S. L., & Ruddell, D. M. (2011). Climate change and health in cities: Impacts of heat and air pollution and potential co-benefits from mitigation and adaptation. *Current Opinion in Environmental Sustainability*, *3*(3), 126–134. https://doi.org/10.1016/j.cosust.2011.01.001

Health Canada. (2011). *Communicating the health risks of extreme heat events: Toolkit for public health and emergency management officials*.

Ho, H. C., Knudby, A., Chi, G., Aminipouri, M., & Lai, D. Y. F. (2018). Spatiotemporal analysis of regional socio-economic vulnerability change associated with heat risks in Canada. *Applied Geography*, *95*(May), 61–70. https://doi.org/10.1016/j.apgeog.2018.04.015

Kaushik, V., & Walsh, C. A. (2018). A Critical Analysis of the Use of Intersectionality Theory to Understand the Settlement and Integration Needs of Skilled Immigrants to Canada. *Canadian Ethnic Studies*, *50*(3), 27–47. https://doi.org/10.1353/ces.2018.0021

Knowlton, K., Rotkin-Ellman, M., King, G., Margolis, H. G., Smith, D., Solomon, G., Trent, R., & English, P. (2009). The 2006 California heat wave: Impacts on hospitalizations and emergency department visits. *Environmental Health Perspectives*, *117*(1), 61–67. https://doi.org/10.1289/ehp.11594

Langlois, E. V., Haines, A., Tomson, G., & Ghaffar, A. (2016). Refugees: Towards better access to

health-care services. *The Lancet*, *387*(10016), 319–321. http://doi.org/10.1016/S0140-6736(16)00101-X

Lin, S., Luo, M., Walker, R. J., Liu, X., Hwang, S. A., & Chinery, R. (2009). Extreme high temperatures and hospital admissions for respiratory and cardiovascular diseases. *Epidemiology*, *20*(5), 738–746. https://doi.org/10.1097/EDE.0b013e3181ad5522

Liu, J. (2019). The Precarious Nature of Work in the Context of Canadian Immigration: An Intersectional Analysis. *Canadian Ethnic Studies*, *51*(2), 169–185. https://doi.org/10.1353/ces.2019.0013

McKeary, M., & Newbold, B. (2010). Barriers to care: The challenges for Canadian refugees and their health care providers. *Journal of Refugee Studies*, *23*(4), 523–545. https://doi.org/10.1093/jrs/feq038

Ngom, R., Gosselin, P., & Blais, C. (2016). Reduction of disparities in access to green spaces: Their geographic insertion and recreational functions matter. *Applied Geography*, *66*, 35–51. https://doi.org/10.1016/j.apgeog.2015.11.008

Newbold, K. B. (2005). Self-rated health within the Canadian immigrant population: Risk and the healthy immigrant effect. *Social Science and Medicine*, *60*(6), 1359–1370. https://doi.org/10.1016/j.socscimed.2004.06.048

O'Lenick, C. R., Wilhelmi, O. V., Michael, R., Hayden, M. H., Baniassadi, A., Wiedinmyer, C., Monaghan, A. J., Crank, P. J., & Sailor, D. J. (2019). Urban heat and air pollution: A framework for integrating population vulnerability and indoor exposure in health risk analyses. *Science of the Total Environment*, *660*, 715–723. https://doi.org/10.1016/j.scitotenv.2019.01.002

Orellana, M. F., Dorner, L., & Pulido, L. (2003). Accessing Assets: Immigrant Youth's Work as Family Translators or "Para-Phrasers." *Social Problems*, *50*(4), 505–524. https://doi.org/10.1525/sp.2003.50.4.505

Paterson, J. A., Ford, J. D., Ford, L. B., Lesnikowski, A., Berry, P., Henderson, J., & Heymann, J. (2012). Adaptation to climate change in the Ontario public health sector. *BMC Public Health*, *12*(1), 1. https://doi.org/10.1186/1471-2458-12-452

Paterson, J., Berry, P., Ebi, K., & Varangu, L. (2014). Health care facilities resilient to climate change impacts. *International Journal of Environmental Research and Public Health*, *11*(12), 13097–13116. https://doi.org/10.3390/ijerph111213097

Radisic, S., & Newbold, K. B. (2016). Factors influencing health care and service providers' and their respective "at risk" populations' adoption of the Air Quality Health Index (AQHI): A qualitative study. *BMC Health Services Research*, *16*(1), 1–11. https://doi.org/10.1186/s12913-016-1355-0

Ruijsbroek, A., Mohnen, S. M., Droomers, M., Kruize, H., Gidlow, C., Gražulevičiene, R., Andrusaityte, S., Maas, J., Nieuwenhuijsen, M. J., Triguero-Mas, M., Masterson, D., Ellis, N., van Kempen, E., Hardyns, W., Stronks, K., & Groenewegen, P. P. (2017). Neighbourhood green space, social environment and mental health: an examination in four European cities. *International Journal of Public Health*, *62*(6), 657–667. https://doi.org/10.1007/s00038-017-0963-8

Shields, S. A. (2008). Gender: An intersectionality perspective. *Sex Roles*, *59*(5–6), 301–311. https://doi.org/10.1007/s11199-008-9501-8

Statistics Canada. (2019). *2016 Census-Boundary Files*. Retrieved from https://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2016-eng.cfm

Statistics Canada. (2019). *Census Profile, 2016 Census*. Retrieved from https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CD&Code1=3525&Geo2=PR&Code2=35&Data=Count&SearchText=hamilton&SearchType=Begins&SearchPR=01&B1=All&TABID

Sterud, T., Tynes, T., Mehlum, I. S., Veiersted, K. B., Bergbom, B., Airila, A., Johansson, B., Brendler-Lindqvist, M., Hviid, K., & Flyvholm, M. A. (2018). A systematic review of working conditions and occupational health among immigrants in Europe and Canada. *BMC Public Health*, *18*(1), 1–15. https://doi.org/10.1186/s12889-018-5703-3

Torralba, J. A. (Tony. (2015). A Survey of Emergent Digital Literacy Inside the Homes of Latino Immigrants in California: Digital Literacy Inside the Homes of Latinos in California. *Journal of International Migration and Integration*, *16*(3), 491–515. https://doi.org/10.1007/s12134-014-0348-2

Watts, N., Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Berry, H., Bouley, T., Boykoff, M., Byass, P., Cai, W., Campbell-Lendrum, D., Chambers, J., Daly, M., Dasandi, N., Davies, M., Depoux, A., Dominguez-Salas, P., Drummond, P., Ebi, K. L., … Costello, A. (2018). The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. *The Lancet*, *392*(10163), 2479–2514. https://doi.org/10.1016/S0140-6736(18)32594-7

Wilson, K., Eyles, J., Elliott, S., & Keller-Olaman, S. (2009). Health in Hamilton neighbourhoods: Exploring the determinants of health at the local level. *Health and Place*, *15*(1), 374–382. https://doi.org/10.1016/j.healthplace.2008.07.002

Windsong, E. A. (2018). Incorporating intersectionality into research design: An example using qualitative interviews. *International Journal of Social Research Methodology*. https://doi.org/10.1080/13645579.2016.1268361

Yardley, J., Sigal, R. J., & Kenny, G. P. (2011). Heat health planning: The importance of social and community factors. *Global Environmental Change*, *21*(2), 670–679. https://doi.org/10.1016/j.gloenvcha.2010.11.010

Zhang, Y., Nitschke, M., & Bi, P. (2013). Risk factors for direct heat-related hospitalization during the 2009 Adelaide heatwave: A case crossover study. *Science of the Total Environment*, *442*, 1–5. https://doi.org/10.1016/j.scitotenv.2012.10.042

Chapter 3

3.1 Introduction

With climate change now a reality, heat waves will continue to become more intense and frequent (Bustinza et al., 2013), with the potential for harmful health effects (Bustinza et al., 2013). Canada will see an increased number of heatwaves, with urban areas being particularly impacted due to the Urban Heat Island (UHI) effect (Paterson et al., 2012). In Canada, extreme heat events (EHEs), otherwise known as heat waves, are defined as three or more days with temperatures at or above 32°C (Health Canada, 2011a). While heat events can be a health threat for all, the elderly, very young, those with pre-existing illnesses, socially isolated, poor, racial minorities (Harlan & Ruddell, 2011), homeless, and those living in communities that are unsafe or have limited access to green space (Campbell et al., 2018) are especially vulnerable to EHEs.

There are a variety of methods to prevent and respond to heat exposure. Beyond reducing GHG emissions, prevention strategies include increasing tree planting for shade and building social networks to reinforce socialization (Guibault et al., 2016). There are also varieties of formal and informal response measures. Formal response measures include structured, pre-planned efforts such as programs or messaging given by service providers. Formal measures may be available at a broader scale and provided by recognized organizations. Response methods include developing heat response plans specifically targeting vulnerable populations such as the homeless (Guibault et al., 2016). Other communities have prioritized availability and access to public cooling spaces (Guibault et al., 2016). Another example is the distribution of water bottles in parks during EHEs by local non-government organizations. These organizations may also have a larger reach within the community because of their existing platform. Informal measures, including those that occur organically among communities include informal methods of information dissemination such as checking on elderly neighbours during EHEs. Informal measures can reach individuals who may otherwise might not have been informed about information related to heat health hazards.

However, there are also weaknesses in formal and informal responses. For example, programming may not be utilized or not recognized by the target population if there are language barriers in the process of information dissemination. Information may not go beyond organizations, thus never reaching the targeted population. Informal methods may result in the spread of watered down or inaccurate information. It is important to assess gaps in formal and informal coping methods to ensure appropriate changes are made to improve efforts. In a diverse country such as Canada, it is especially important that public health measure evolve to account for the needs of newcomers and immigrants. Therefore, efforts should be made

to assess if coping strategies to reduce health vulnerabilities during EHEs among the newcomer and immigrant population are accessible and effective.

This study will focus on Hamilton, Ontario, a diverse city located in the southern part of the province and on Lake Ontario (Figure 1). The purpose of this chapter is to explore formal and informal EHE coping measures in Hamilton that are directed at the immigrant population. By considering a group that may not be primarily viewed as vulnerable to EHEs, this study will add to efforts to improve responses to EHEs in Hamilton. It will also highlight how this population may fit in with broader climate change adaptation strategies.

3.2 Literature Review

3.2.1 Current Adaptation and Mitigation Efforts

Various mitigation and adaptation initiatives can be implemented to reduce the risk and impacts of EHEs. To mitigate the risks of EHEs, a variety of long-term strategies should be used to increase green space and improve building design (Howard et al., 2018). The environment plays an important role on the impact of extreme heat events (Graham et al., 2016, 2017). Areas with less tree canopy have been found to have a higher number of heat-related ambulance calls (Graham et al., 2016). The number of heat-related ambulance calls could be reduced by cooling an area through landscape design (Graham et al., 2017). Houses and apartments should also be built to reduce the exposure inhabitants may have to extreme heat (Bambrick et al., 2011).

Adaptation efforts to reduce the impacts of EHEs are also important. Overall, efforts should be made to improve forecasting and knowledge translation activities (Howard et al., 2018). Maps can also be a useful tool to assess and respond to heat vulnerability (Rinner et al., 2010). Heat action plans (HAP), such as those created for Montreal, have also been found to help reduce mortality, specifically among elderly and those in neighbourhoods with lower levels of education (Benmarhnia et al., 2016). Socioeconomic status is also important to consider for understanding environmental issues. For example, one study noted that an understanding of the Air Quality Health Index (AQHI) was higher among those with greater socio-economic status (Radisic & Newbold, 2016). Thus, efforts must be made to educate vulnerable groups with lower socio-economics status (Radisic & Newbold, 2016). This can be done through interventions led by service providers (Radisic & Newbold, 2016). Increasing social capital could also reduce the risk of heat-related illnesses among vulnerable populations (Bambrick et al., 2011). Although newcomers and immigrants are resilient (Hansen et al., 2014), research also concludes that adaptation strategies must recognize different ethnicities (Hansen et al., 2013). In cases where individuals do not have access to broadcast media, primarily recent immigrants, charity groups, social workers and networks of family and

friends are important in relaying information (Hansen et al., 2013). To reduce mortality and morbidity, culturally appropriate service announcements are necessary. Vulnerable population, including ethnic minorities should be a focus when developing heat warning messages (Hansen et al., 2013). Language may also be a barrier to accessing information of heat (Hansen et al., 2014). Furthermore, limited awareness of where to access help and knowledge about health were factors that especially affected the health of refugees in one Australian study (Hansen et al., 2014). One study also highlighted that short-term adaptation strategies should begin with an assessment to determine who is at risk, developing disaster response plans and ensuring that access to public spaces with air conditioning, primarily for those with lower socioeconomic status (Cheng & Newbold, 2010).

3.2.2 Risk Perception

Overall, risk perception can be defined as the beliefs around possible negative consequences (Brewer et al., 2007). However, as various fields contribute to assessing risk perception, the underlying definition remains the same while the emphasis may be put on different factors depending on the field of study (Bee, 2016). For example, risk perception can be influenced by the type of hazard, as well as the severity and frequency of the hazard (Bee, 2016). It can also be influenced by social and cultural factors, as well individual levels of tolerance (Bee, 2016). It can play an important role in general climate change adaptation and is also important to consider when looking at heat health vulnerability (Berry et al., 2014). One study assessed how the health sector perceives agency for climate change adaptation (Paterson et al., 2012). Actors within the public health sector noted that adaptation is limited when there is a lack of urgency among political leaders, highlighting the importance of risk perception among leaders in larger organizations (Paterson et al., 2012). Communication about climate change in the community can also be difficult when local citizens have limited awareness about personal risks (Paterson et al., 2012). Confusion about mitigation versus adaptation is also common (Paterson et al., 2012). Communicating about climate change is especially difficult in communities that are diverse (Paterson et al., 2012). Unless environmental health risks are currently visible, they are not a concern to local residents (Cardwell & Elliott, 2013). It is important to assess what health officials know to assess what is needed in educational efforts moving forward (Hathaway & Maibach, 2018). This would then help them better serve their communities (Hathaway & Maibach, 2018). Overall, many health professionals in North America are aware of the negative health consequences related to climate change, but also recognize that greater financial and human resources are needed to effectively address the problem (Hathaway & Maibach, 2018).

Overall, research highlights current heat health mitigation and adaptation efforts, with some studies specifically focusing on efforts that target the newcomer and immigrant population. However, there is a need in Canada to assess if and how strategies consider the newcomer and immigrant population.

Furthermore, although much of the existing research focuses on risk perception for the broader topic of climate change, it can still be considered when assessing reasons for knowledge gaps about heat events, specifically among service providers. Currently, there is limited research in Canada that assesses how service providers from housing, health and newcomer services perceive heat health risks. Furthermore, research is needed to assess how newcomers and immigrants perceive heat health risks, and how this may affect their individual coping strategies. An understanding of risk perception and its barriers are important, as it can influence how individuals prepare for and perceive an EHE, which then impacts formal and informal coping strategies. This study will work to start filling some of these research gaps.

3.3 Methods

3.3.1 Study Area

As of 2016, the City of Hamilton had a population 536, 917, with immigrants making up about a quarter of the population (Hamilton Immigration Partnership Council, 2019). In addition, there were about 24, 535 refugees (Statistics Canada, 2019). In 2016-2017, approximately two-thirds of the city's growth was attributed to immigration (Hamilton Immigration Partnership Council, 2019). By 2041, the city is expected to grow by 40%, with immigration playing a large role in this. Hamilton is made up of six communities: Ancaster, Stoney Creek, Dundas, Flamborough, Glanbrook, and Hamilton. The Niagara Escarpment divides the city, with a higher proportion of low-socioeconomic individuals living in the lower city, and wealthier individuals typically residing in the upper city (Radisic & Newbold, 2016). Although immigrants settle in various parts of the city, a larger share are found in the inner, older part of Hamilton as well as the east end, including Stoney Creek. The east end of the city seems to be an especially important area for immigrant settlement, as regardless of year of arrival, many choose to live there (Hamilton Immigration Partnership Council, 2019). English is the language most often spoken at home among 83.8 percent of Hamiltonians (Statistics Canada, 2019). Industrial, education and health care sectors are a significant part of the city (Agyekum & Newbold, 2016; Wilson et al., 2009).

Those aged 65 years and older make up about 17 percent of Hamilton's population (Statistics Canada, 2019). More specifically, older age groups make up a large portion of the immigrant population (Hamilton Immigration Partnership Council, 2019), however, the population of recent immigrants is younger than non-immigrants in the city (Hamilton Immigration Partnership Council, 2019). Those aged 25 to 45 compromise 25 percent of Hamilton's population, yet those ages 25-45 attribute to about 45 percent of recent immigrants (Hamilton Immigration Partnership Council, 2019; Statistics Canada, 2019). Some 6.7 percent of all immigrants in Hamilton are ages 45 years and older (Statistics Canada, 2019). There is also a higher proportion of females compared to males among recent immigrant (Hamilton Immigration Partnership Council, 2019).

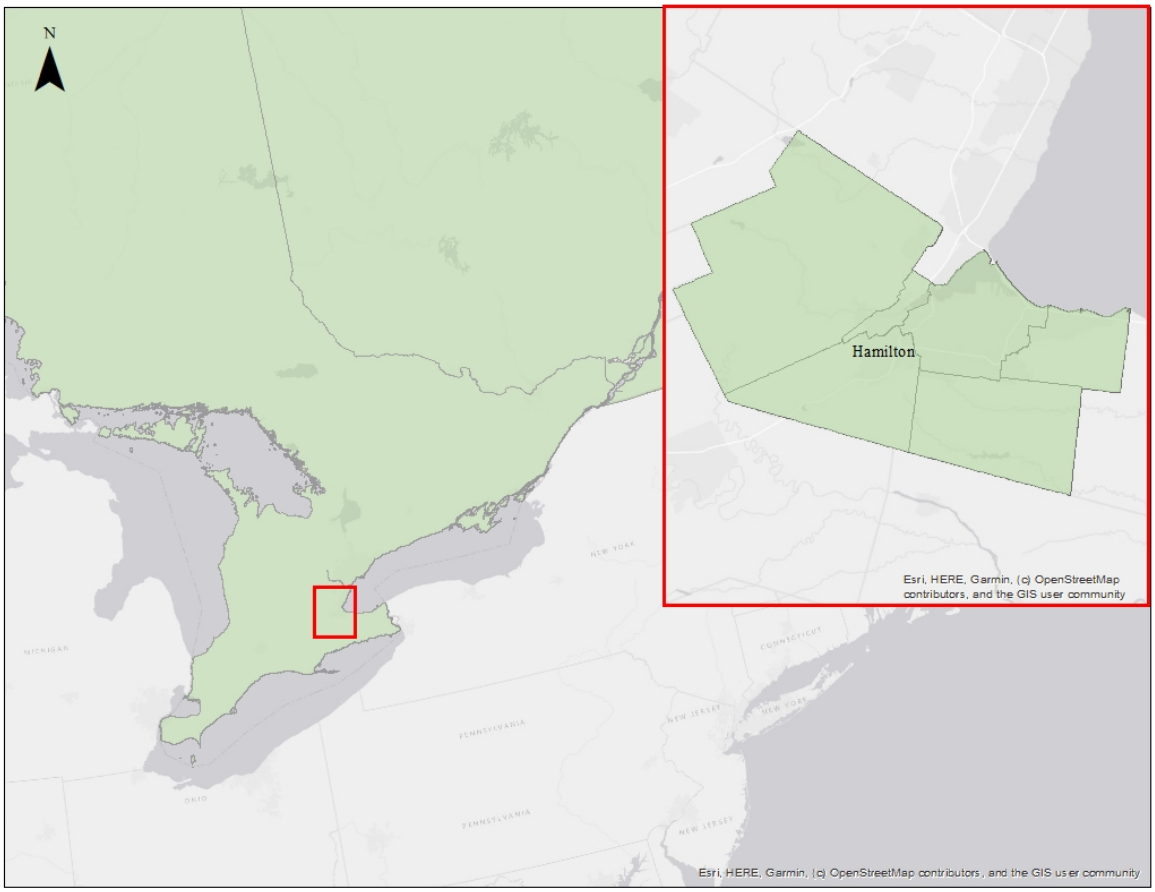

Figure 1: The study site, Hamilton, Ontario (City of Hamilton, 2018; Statistics Canada, 2019).

3.3.2 Recruitment

A diverse group of service providers, from both government and non-government organizations in Hamilton were recruited. Interviewees included those working in language services (1), newcomer settlement (2), housing (4) and health (5). The initial method of recruitment was convenience sampling. Providers who were personally known to the investigators were contacted by telephone and email. Snowball sampling was also used to connect with other participants who would be a good fit for this study. From July to December of 2019, interviews took place on a rolling basis. In total, 12 interviews were conducted. Interviewees were provided with anonymity, with results using numbered quotes to identify the respondent.

3.3.3 Conducting Interviews

A total of 11 interviews were conducted in-person at the interviewee's place of employment and 1 interview was conducted over the phone. Each interview was audio recorded and supplemented with handwritten notes, ensuring the inclusion of additional key information (e.g. about body language, or questions or concerns from the participants). Each interview lasted approximately 30 minutes. One

interview was conducted with two people, and another with four people. The rest of the interviews were one-on-one. Interview guides were utilized to conducted semi-structured interviews. Participants were asked about their general knowledge of heat events, as well as mitigation and adaptation efforts related to EHEs (see Appendix A). There were also questions about the potential vulnerability of newcomers and immigrants in Hamilton, followed by questions about their job.

3.3.4 Analysis

Following interview transcribing, deductive coding was used to develop a list of potential themes based on the current literature. For the first coding cycle, interviews were analyzed with a code (keyword or phrase) assigned to a message or theme in the transcript. Codes were based on the initial list of themes, and emerging themes based on inductive reasoning. The principal investigator reviewed two transcripts to ensure the use of appropriate and consistent codes. This was followed by a second coding cycle. Codes were cleaned, and similar codes were grouped together to ensure consistency. Then codes were categorized under sub-themes and general themes, and broader themes if necessary.

4. Results

The following presents two main themes derived from the transcripts, including current adaptation and mitigation efforts and impacts on long-term strategies.

4.1 Current adaptation and mitigation efforts

4.1.1 Formal Methods: Education and Outreach

Service providers highlighted current formal methods of coping with EHEs, including strategies used to spread awareness about heat events before they occur as well as warnings and recommendations during heat alerts.

"So, if there is an extreme heat event, I know that some of our providers will, they'll go door to door. So, they'll talk to them, they'll put signs up, which I think primarily are in English. But some of the providers with more resources may have it up in other languages, as well…"-6

However, such outreach methods may reach a rather limited audience given the scope of the population. This in-person outreach is also complicated if messages are primarily given in English. Financial resources are needed to create posters in multiple language. This is similar to existing research where health professionals highlight the need for greater financial resources (Hathaway & Maibach, 2018). If information is only available in English, many individuals may not be able to receive the information, reducing the reach of information dissemination and affecting risk perception, because individuals are not informed about the potential harmful impacts of EHEs.

Information is also delivered in a more targeted manner through educational opportunities available to newcomers. One service delivery organization in the city offers a class to newcomers to assist their settlement, with part of the curriculum covering Canadian weather:

"We provide information sessions about living in Canada [to newcomers]. In a case of extreme heat what they should do, extreme cold what they should do. If there's a snow day, what they should do, or if there's a snowstorm, what they should do. With heat, yes, we invite public health services to come and talk to the students. Also, one of the programs we have…part of the class is talking about the environment."-3

But this invites the question of when these sessions are taking place: If they are not in the spring or summer, participants may not remember information about health risks during periods of hot weather, nor fully understand the climatic extremes experienced in the city. Discussing heat events in January is likely less effective than later in the spring when warm temperatures return. Furthermore, a challenge with formal methods is reaching those that are particularly vulnerable to EHEs. Social networking and physically going door-to-door to check on individuals are important avenues to address EHEs, as one participant from public health noted:

"We also recommend that, you know, people check on their neighbors, right, in some of our messaging to say, you know, if you know somebody who's a neighbor, it's a senior, and they're alone, perhaps you want to check on them and make sure that they're okay. It's encouraged during those heat events. So, I think we try to target seniors via those traditional sort of notification pathways, right? As opposed to, for example, social media…"-12

This quote highlights the importance of digital access and literacy, and the potential problems with information dissemination if there is limited knowledge or access to digital communication, a concern among those with limited financial resources and lack of access to technology. To reach a larger audience, various forms of media should be used for public warnings (Hansen et al., 2013), including newspapers, radio, and television (Hansen et al., 2013). Access to media, and specifically local media, can help inform individuals about the urgency of the risk and adaptation strategies, influencing risk perception. But, these sources, unless they are cultural media outlets, also tend to provide information in English only, thus reinforcing the difficulty of disseminating information.

All three of the above quotes also highlight the importance of social networks, whether they are through general outreach programs, structured classes via service providers, or relationships developed among neighbours. Social networks can be an important source of information dissemination for recent immigrants without access to media outlets (Hansen et al., 2013). When individuals perceive extreme heat events to be a health risk, they can take appropriate steps to help themselves and others, underlining the importance of social networks. Collectively, the results suggest that the communication of health events to immigrants and other vulnerable groups needs to be improved, particularly in light of climate change adaptation (Cheng

and Newbold, 2010) to ensure the most vulnerable populations can reduce their risks associated with climate change.

Providers also highlighted that formal methods of managing and communication around EHEs are not necessarily comprehensive, as they may lack a systematic method of information dissemination, or emergency plans may not include a category for heat alerts. Despite public health measures, the messaging may change, shift, or not reach the intended audience as other providers relay the information further. Two housing services highlighted this during their interviews:

"We will normally put weather advisories on our website…we're passive in that we post it when we get a notice, we're not active in terms of looking…"-2

"…all the housing providers, the non-profit housing providers, have their own emergency plans right now. I don't know whether or not their plans specifically deal with extreme heat events…"-6

There are also potential gaps in heat emergency preparedness among service providers in Hamilton, with service providers highlighting that they are limited in their ability to help clients with this issue based on a lack of knowledge, a reliance on the city to provide notice of heat events, or a failure to prioritize heat events and information dissemination.

"I mean, I don't know where we could direct them if that…I don't know…We can suggest like shower. You know, find another fan like, general things that we know. Because we're obviously not qualified to give them advice…"-1

"I think lack of knowledge is another potential barrier…None of us had put our minds to it, hadn't really thought about this as an upcoming thing we should plan for it. And so, we haven't thought about it. I think a general knowledge for the residents as well that in these kinds of temperatures and prolonged periods of time, stay hydrated, what are the signs of heatstroke, that kind of thing"-7

A lack of knowledge about this issue among service providers reveals their inability to provide help if needed. This is important to consider moving forward for heat emergency planning. Service providers who work with vulnerable populations should be equipped with knowledge about heat health risks to help those they work with. This reveals the need and opportunity for public health workers to expand their existing services, providing more support for heat health education. This also emphasizes the need for local stakeholders and government agencies to further collaborate to meet the needs of the community.

4.1.2 Informal Methods: Connecting Service Providers with Clients

Participants also discussed informal methods of coping with and communicating about EHEs in Hamilton.

"I know that people who are affected are looking for places where they can go, like I know some, like the elderly immigrants, they will go to (name of public place) or (name of public place) or another place that they can be cool. But not because they hear the information, but because they are naturally drawn to groups to go to those places to stay cool."-11

This quote highlights natural coping strategies taken as individuals try to reduce their personal risk to heat events, emphasizing the importance of public spaces with cooling, and the importance of social networks. Participants working within healthcare further highlighted the significance of social networks:

"Generally, they have to be given the information because they don't know, because of where they are coming from, they don't know how to ask or what to ask. They don't know what there is for them, that has to be out in the open, and they go on from there and let their peers know about these services, so the program broadens from there on. This core group will take the message from the school, and will tell their peers, their friends, people in their building and it goes from there."-8

This quote builds on the theme mentioned earlier, revealing the organic dissemination of knowledge via social networks. It also highlights the knowledge gap among newcomers about heat health risks.

"Another thing I wanted to say before I forget is, for how to get that information out, I think it's really important that there's a connection with service providers who interface with the immigrants, to get the information out… Because a lot of these service providers have a lot of unique ways to connect with their clients…You know, so maybe there's ways you can get information out in a way that gets it to a broader group, to people that they're already connected to."-8

Overall, social networks can be crucial to filling the knowledge gap about heat health impacts and adaptation, and these connections can provide information through various social media platforms. Disconnection to support networks reduces their social network, which may already be limited if they are a newcomer (McKeary & Newbold, 2010), as newcomers found there was less socialization in the country they moved to, in comparison to their country of origin (Hansen et al., 2014). Those living on their own often have less support and a greater risk of negative health consequences (Zhang et al., 2013). Overall, these quotes highlight the importance of informal coping strategies during periods of hot weather in Hamilton.

4.2 Impact on long-term strategies

Understanding heat health risks among stakeholders is crucial to ensuring that communities can work together to adapt using long-term comprehensive strategies (Health Canada, 2011b). With long-term strategies, communities can help to ensure they keep up with a changing environment while maintaining, or improving, individual health and well-being. In this study, housing service providers highlighted that heat health risks are relevant as they plan for the future in terms of housing and general messaging and provision of information.

"While we're finding with that situation now is that heat is becoming, I should say, the apartment reverse building cooling is as much of a concern to us as building heating going forward, and you know, with the …building codes are changing and stuff but they're not retroactive. So, going forward we're saying, we know that we've got an aging population, we know that we've got to have cooling built into these buildings."-2

This specifically reveals the importance of thinking about long-term heat adaptation strategies. As this participant from the housing sector noted, strategies are not always implemented with the future in mind. Thinking ahead is crucial to not only prevent negative impacts associated with heat events, but also to avoid having to adapt later on.

"But I know one of the things that we're trying to do with our housing providers, and it's sort of more a broader issue…But we are, when we do have calls for applications for capital repairs and retrofits, we do have a component in there that talks about reducing greenhouse gas emissions. So, there is awareness. And there are efforts to improve HVac systems to improve roofs, to improve all of those elements that make apartment dwellings or make townhouses…to help deal with the heat that actually exists within the unit."-6

Both quotes highlight that risks associated with heat events are becoming increasingly relevant to some service providers in Hamilton. Adaptation should include increasing air conditioning in both public and private spaces, and specifically making efforts to cool houses (Cheng and Newbold, 2010). Structural improvements to homes and the utilization of smarter technology are also necessary to reduce the need for air conditioning, while reducing negative health impacts of heat (Hansen et al., 2014). Looking at long-term solutions will help to mitigate the risks associated with periods of heat.

5. Discussion and Conclusion

Overall, this study highlights that while efforts have been made to provide information and adapt to extreme heat events in Hamilton, these efforts are not always comprehensive and may lack long-term thinking. Many service providers see the health risks related to EHEs yet may not have the resources or knowledge to fully implement coping strategies. In some cases, efforts may be passive, likely due to EHEs not being a priority. Discussions about formal and informal methods emphasized the importance of various methods of information dissemination, the availability of cool private and public spaces as well as social networks. Gaps in knowledge among service providers were briefly discussed, revealing the need for more accessible educational resources for community stakeholders. Participants also highlighted that extreme heat events are important to consider because they influence long-term strategies in Hamilton.

Risk perception can shape the urgency for the development of education and strategies at the broader level, among public health officials, to service providers working with smaller populations. Consequently, risk perception also dictates how the issue of heat health is prioritized in comparison to other issues in a community. If service providers and community members are more concerned about other issues, then efforts to adapt to extreme heat events may be limited.

In general, climate change adaptation should start with community assessments, identifying populations at risk, followed by strategies that reflect the needs of the local area (Cheng and Newbold, 2010). This also applies more specially when planning for extreme heat events and, moving forward, it is

important to consider these factors and take a comprehensive approach, reducing the negative impacts of extreme heat on vulnerable populations, specifically those in the immigrant community. Often, the poor and socially isolated are not included in heat emergency plans (Yardley et al., 2011). Strategies for climate change adaptation need to be inclusive to a variety of ethnicities (Hansen et al., 2013), and once again, this includes adaptation efforts for multiple impacts related to climate change, including extreme heat events.

More specifically, heat emergency planning should be made in collaboration with community stakeholders and various levels of government (Yardley et al., 2011). Doing so would highlight how different factors interact to create vulnerability, providing evidence that adaptation strategies should consider social, physical and economic issues (Yardley et al., 2011). If various sectors are involved, this may also help to ensure that extreme heat is considered in long-term planning. Collaboration across sectors could also help service providers develop and utilize effective heat emergency plans and help to protect the most vulnerable community members, ensuring they are equipped to help newcomers and immigrants deal with EHEs, even if it is not their primary area of work. This way, even if a newcomer or immigrant has limited social connections, specifically in regard to service providers, they still receive this information, because service providers across sectors are knowledgeable about heat health adaptation. Even if newcomers and immigrants are aware of the issue, they may rely on social networks to inform them about formal services. Perceptions about heat health risks among newcomers and immigrants may influence their uptake of informal coping mechanisms.

It is also important to note that the data collection for this study was completed before the COVID-19 pandemic began. From an individual standpoint, the pandemic increased the risk of social and physical isolation, with older adults potentially trapped in hot apartments and fewer social interactions. Moving forward, heat emergency adaptation strategies will have to consider what it looks like to have large groups of people in public cooling spaces, with potential alternatives for physical distancing and adequate cleaning. For 2020, Toronto Public Health provided guidelines for landlords operating cooling rooms for tenants (Toronto Public Health, 2020) while the opening of public cooling centers also posed challenges. Some of these strategies may have to continue to be applied even once the threat of the pandemic passes.

This study did not include participants from the newcomer population, limiting insights. Moving forward, research should include this group as participants to reveal more about how they cope with heat events. Nevertheless, this research provides a solid starting point for heat health research in Hamilton, as it highlights existing efforts as well as gaps in current strategies. More research is needed to effectively address the issue of heatwaves in Hamilton as broader climate change mitigation and adaptation strategies are implemented.

References

Agyekum, B., & Newbold, K. B. (2016). Sense of Place and Mental Wellness of Visible Minority Immigrants in Hamilton, Ontario: Revelations from Key Informants. *Canadian Ethnic Studies*, *48*(1), 101–122. https://doi.org/10.1353/ces.2016.0001

Bambrick, H. J., Capon, A. G., Barnett, G. B., Beaty, R. M., & Burton, A. J. (2011). Climate change and health in the Urban environment: Adaptation opportunities in Australian cities. *Asia-Pacific Journal of Public Health*, *23*(2 SUPPL.). https://doi.org/10.1177/1010539510391774

Bee, B. A. (2016). Power, perception, and adaptation: Exploring gender and social-environmental risk perception in northern Guanajuato, Mexico. *Geoforum*, *69*, 71–80. https://doi.org/10.1016/j.geoforum.2015.12.006

Benmarhnia, T., Bailey, Z., Kaiser, D., Auger, N., King, N., & Kaufman, J. S. (2016). A difference-in-differences approach to assess the effect of a heat action plan on heat-related mortality, and differences in effectiveness according to sex, age, and socioeconomic status (Montreal, Quebec). *Environmental Health Perspectives*, *124*(11), 1694–1699. https://doi.org/10.1289/EHP203

Berry, P., Clarke, K., Fleury, M.D. and Parker, S. (2014): Human Health; in Canada in a Changing Climate: Sector Perspectives on Impacts and Adaptation, (ed.) F.J. Warren and D.S. Lemmen; Government of Canada, Ottawa, ON, p. 191-232.

Brewer, N. T., Chapman, G. B., Gibbons, F. X., Gerrard, M., McCaul, K. D., & Weinstein, N. D. (2007). Meta-analysis of the relationship between risk perception and health behavior: The example of vaccination. *Health Psychology*, *26*(2), 136–145. https://doi.org/10.1037/0278-6133.26.2.136

Bustinza, R., Lebel, G., Gosselin, P., Bélanger, D., & Chebana, F. (2013). Health impacts of the July 2010 heat wave in Québec, Canada. *BMC Public Health*, *13*(1). https://doi.org/10.1186/1471-2458-13-56

Campbell, S., Remenyi, T. A., White, C. J., & Johnston, F. H. (2018). Heatwave and health impact research: A global review. *Health and Place*, *53*(August), 210–218. https://doi.org/10.1016/j.healthplace.2018.08.017

Cardwell, F. S., & Elliott, S. J. (2013). Making the links: Do we connect climate change with health? A qualitative case study from Canada. *BMC Public Health*, *13*(1), 1. https://doi.org/10.1186/1471-2458-13-208

City of Hamilton. (2018). *Community Boundaries* . Retrieved from https://open.hamilton.ca/datasets/fdfe2c5081c5459f8aae7f1861a24b15_17

Cheng, J & Newbold B. (2010). Mapping vulnerability to climate change and variability in Hamilton, Ontario using geographical information systems.

Graham, D. A., Vanos, J. K., Kenny, N. A., & Brown, R. D. (2016). The relationship between neighbourhood tree canopy cover and heat-related ambulance calls during extreme heat events in Toronto, Canada. *Urban Forestry and Urban Greening*, *20*, 180–186. https://doi.org/10.1016/j.ufug.2016.08.005

Guibault, S., Kovacs, P., Berry, P., & Richardson, G. R. A. (2016). *Cities Adapt to Extreme Heat*. 110. https://www.iclr.org/images/Cities_Adapt_to_Extreme_Heat_online.compressed.pdf

Hamilton Immigration Partnership Council (Instituation/Organization). (2019). *A demographic profile of immigrants in Hamilton*.

Hansen, A., Bi, L., Saniotis, A., & Nitschke, M. (2013). Vulnerability to extreme heat and climate change: Is ethnicity a factor? *Global Health Action*, *6*(1). https://doi.org/10.3402/gha.v6i0.21364

Hansen, A., Nitschke, M., Saniotis, A., Benson, J., Tan, Y., Smyth, V., Wilson, L., Han, G. S., Mwanri, L., & Bi, P. (2014). Extreme heat and cultural and linguistic minorities in Australia: Perceptions of stakeholders. *BMC Public Health*, *14*(1). https://doi.org/10.1186/1471-2458-14-550

Harlan, S. L., & Ruddell, D. M. (2011). Climate change and health in cities: impacts of heat and air pollution and potential co-benefits from mitigation and adaptation. *Current Opinion in Environmental Sustainability*, *3*, 126–134. https://doi.org/10.1016/j.cosust.2011.01.001

Hathaway, J., & Maibach, E. W. (2018). Health Implications of Climate Change: a Review of the Literature About the Perception of the Public and Health Professionals. *Current Environmental Health Reports*, *5*(1), 197–204. https://doi.org/10.1007/s40572-018-0190-3

Health Canada. (2011a). *Communicating the health risks of extreme heat events: Toolkit for public health and emergency management officials*.

Health Canada. (2011b). *Extreme Heat Events Guidelines: Technical Guide for Health Care Workers.*

Howard, C., Caren, R., & Rivers, N. (2018). *Lancet Countdown 2018 Report : Briefing for Canadian Policymakers* (Issue November). https://dighr.yorku.ca/files/2019/03/Canadian-Countdown-Brief-2018.pdf?x44472

McKeary, M., & Newbold, B. (2010). Barriers to care: The challenges for Canadian refugees and their health care providers. *Journal of Refugee Studies*, *23*(4), 523–545. https://doi.org/10.1093/jrs/feq038

Paterson, J. A., Ford, J. D., Ford, L. B., Lesnikowski, A., Berry, P., Henderson, J., & Heymann, J. (2012). Adaptation to climate change in the Ontario public health sector. *BMC Public Health*, *12*(1), 1. https://doi.org/10.1186/1471-2458-12-452

Radisic, S., & Newbold, K. B. (2016). Factors influencing health care and service providers' and their respective "at risk" populations' adoption of the Air Quality Health Index (AQHI): A qualitative study. *BMC Health Services Research*, *16*(1), 1–11. https://doi.org/10.1186/s12913-016-1355-0

Rinner, C., Patychuk, D., Bassil, K., Nasr, S., Gower, S., & Campbell, M. (2010). The Role of Maps in Neighborhood-level Heat Vulnerability Assessment for the City of Toronto. *Cartography and Geographic Information Science*, *37*(1), 31–44. http://doi.org/10.1559/152304010790588089

Statistics Canada. (2019). *2016 Census-Boundary Files*. Retrieved from https://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2016-eng.cfm

Statistics Canada. (2019). *Census Profile, 2016 Census*. Retrieved from https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CD&Code1=3525&Geo2=PR&Code2=35&Data=Count&SearchText=hamilton&SearchType=Begins&SearchPR=01&B1=All&TABID

Toronto Public Health. (2020, August 14). *COVID-19 guidance for cooling rooms*. Retrieved August 242020, from https://www.toronto.ca/wp-content/uploads/2020/05/958d-COVID-19_Fact-Sheet_Cooling-Rooms.pdf

Wilson, K., Eyles, J., Elliott, S., & Keller-Olaman, S. (2009). Health in Hamilton neighbourhoods:

Exploring the determinants of health at the local level. *Health and Place*, *15*(1), 374–382. https://doi.org/10.1016/j.healthplace.2008.07.002

Yardley, J., Sigal, R. J., & Kenny, G. P. (2011). Heat health planning: The importance of social and community factors. *Global Environmental Change*, *21*(2), 670–679. https://doi.org/10.1016/j.gloenvcha.2010.11.010

Zhang, Y., Nitschke, M., & Bi, P. (2013). Risk factors for direct heat-related hospitalization during the 2009 Adelaide heatwave: A case crossover study. *Science of the Total Environment*, *442*, 1–5. https://doi.org/10.1016/j.scitotenv.2012.10.042

Chapter 4

4.1 Introduction

Climate change will continue to affect the world, with impacts varying by region. The frequency, intensity and severity of extreme heat events (EHEs) is expected to increase (Campbell et al., 2018), with cities being especially impacted due to the Urban Heat Island (UHI) effect (Harlan & Ruddell, 2011). With changes in meteorology, air quality may also be impacted (Harlan & Ruddell, 2011). In the summer, increased temperature can contribute to air pollution (Harlan & Ruddell, 2011), as temperature influences the concentration of pollutants, specifically ozone (Ren et al., 2008). EHEs and poor air quality can have adverse impacts on human health (Harlan & Ruddell, 2011). Heat related illnesses include renal and cardiovascular disease, and heat stress (Nick Watts et al., 2018). Air pollution may also exacerbate illnesses, with cardiovascular disease, chronic obstructive pulmonary disease, asthma, diabetes and hypertension particularly impacted by poor air quality (To et al., 2015).

An increase in the use of health services has been shown to result from EHEs (Bishop-Williams et al., 2015; Calkins et al., 2016; Soneja et al., 2016) and air pollution (To et al., 2015). Overall, the elderly, those with pre-existing health conditions, very young, poor, ethnic minorities and socially isolated are especially at risk of greater exposure and vulnerability to EHEs and poor air quality (Harlan & Ruddell, 2011). Canadians are not an exception to the negative impacts of EHEs and air pollution (Howard et al., 2018). Heat and Humidex advisories are issued by Environment and Climate Change Canada "when temperatures are expected to reach or exceed 30°C and/or the humidex value is expected to reach or exceed 40 on the Humidex scale of perceived temperature (Health Canada, 2011). Extreme heat events (EHEs), also known as heat waves, occur when temperatures remain at about 32°C for more than three consecutive days (Health Canada, 2011). Maximum temperatures, as opposed to mean temperatures are used to assign heat waves in Canada (Bishop-Williams et al., 2015). In Ontario, the Air Quality Health Index (AQHI) is used to indicate the relationship between air quality in a specific location and human health (Ministry of the Environment, Conservation and Parks, n.d.). Ground-level Ozone (O_3), Fine Particulate Matter ($PM_{2.5}$) and Nitrogen Dioxide (NO_2) are used in the AQHI to provide an indication of outdoor air quality (Ministry of the Environment, Conservation and Parks, n.d.).

This study will focus on Hamilton, Ontario. With a 2016 population of 536, 917 (Statistics Canada, 2019), Hamilton is a diverse city, with immigrants making up about a quarter of the city's population with 130, 365 individuals (Hamilton Immigration Partnership Council, 2019). The total number of refugees was 24, 535 (Statistics Canada, 2019). Slightly more than 17 percent of the total population is 65 years and older (Statistics Canada, 2019). Situated at the western end of Lake Ontario, Hamilton's climate is humid continental and characterized by cold winters and hot, humid summers. From 1976 to 2005, the number of

days with temperatures above 30°C was 16.1, and this is expected to increase to 63.3 from 2051-2080 (Climate Atlas, 2019).

With a focus on the City of Hamilton, Ontario, the proposed work extends our understanding of the impacts of heat events by looking at the relationship between heat events, poor air quality, and hospital admissions. This would help determine how to include these populations in climate change adaptation policies. Given Hamilton's history of air pollution in certain areas of the city (Radisic et al., 2016), it is important to assess the impact of air quality on heat-related illnesses during EHEs, with a specific focus on hospital admissions. Hamilton is also home to several hospitals, and a general assessment should be done to determine if hospital services are accessed more during EHEs. This can be used to motivate future resource allocation decisions in Hamilton hospitals.

Using quantitative methods, the objectives of this project are to: 1) Explore if there is a relationship between EHEs, air quality and hospital admissions in Hamilton; 2) Explore the geography of hospital admissions, represented by forward sortation areas (FSAs), within the city.

4.2 Literature

4.2.1 Impacts of EHEs on Hospital Admissions

Studies have taken place in various regions across North America, including California, Quebec and Southern Ontario, to highlight how hospitalizations and visits to emergency departments increase during extreme heat events (Bishop-Williams et al., 2015; Bustinza et al., 2013; Knowlton et al., 2009). Heat waves can be identified by retrieving data from national climate archives, such as those housed by Environment Canada, or by analyzing media reports to determine the data of heat waves and compare them with national definitions (Bishop-Williams et al., 2015; Bustinza et al., 2013). Meteorological indicators can include temperatures, apparent temperature and/or relative humidity (Lin et al., 2009). In Canada, daily maximum temperatures are used to define heat waves (Bishop-Williams et al., 2015). To study increases in emergency department visits, hospitalizations and mortality, a reference period before and/or after the heat wave in question is used for comparison (Bishop-Williams et al., 2015; Bustinza et al., 2013; Knowlton et al., 2009). Data related to hospitalization and emergency visits can be retrieved through a variety of methods, which may include, directly from the hospital records departments or regional ministries/departments of health (Bishop-Williams et al., 2015; Bustinza et al., 2013). One study revealed hospitalizations and emergency department visits increase greatly during heat waves (Knowlton et al., 2009). However, in the case of the 2006 heat wave in California, there was a greater increase in emergency department visits for all causes and ages, while the increase in hospitalizations was not as substantial (Knowlton et al., 2009). Some studies have highlighted that visits specifically to emergency departments increase (Bishop-Williams et al., 2015; Bustinza et al., 2013). The overall increase in emergency

department admission has been evident in rural areas (Bishop-Williams et al., 2015). Emergency department and hospitalizations significantly increased specifically for heat related illness and other illnesses such as electrolyte imbalance and acute renal failure (Knowlton et al., 2009). One study concluded that once a certain threshold in temperature and apparent temperature are reached, hospital admissions for respiratory and cardiovascular diseases increases (Lin et al., 2009). Overall, studies show an increase in hospitalizations and emergency visits during EHEs.

Certain populations are more likely to be admitted to the hospital during extreme heat events. Geographic location, age, disease, and ethnicity can all influence individual vulnerability to extreme heat events (Knowlton et al., 2009; Lin et al., 2009). For example, in New York City, those of Hispanic ethnicity with existing respiratory illnesses were at greater risk of being admitted to hospitals in contrast to those of non-Hispanic ethnicity (Lin et al., 2009). This was potentially because minority groups have a higher likelihood of residing in urban areas, and often unable to afford air-conditioners in their homes (Lin et al., 2009). Emergency department visits have also been observed to increase amongst whites with diabetes and Latino individuals with cardiovascular disease (Lin et al., 2009). There is also evidence that individuals 65 years and older are admitted to hospitals more than other age groups during EHEs (Lin et al., 2009).

Studies use a variety of geographic scales to assess the impacts of extreme heat on hospital admissions, including individual cities, counties and health regions, as defined by different governments (Bustinza et al., 2013; Knowlton et al., 2009; Lin et al., 2009). Regional differences have also been evident (Knowlton et al., 2009). An increase emergency department visits during a heat wave has been evident for those with diabetes, respiratory illnesses, and cardiovascular illness in the Central Coast of California (Knowlton et al., 2009). This may be a result of an inability of residents, who reside in cooler temperatures, to acclimate to warmer conditions (Bishop-Williams et al., 2015; Knowlton et al., 2009). Similarly, those living in Ontario, which has a cooler climate, might be more vulnerable to extreme heat events in comparison to individuals residing areas with warmer climates (Bishop-Williams et al., 2015). Residing in cities can also impact heat vulnerability. In comparison to rural areas, cities have shown to have higher temperature, which is known as the urban heat island effect (UHI) (Susca, Gaffin, & Dell'Osso, 2011), resulting from less green space and the abundance of buildings which also contribute to warmer environments due to their thermal properties (Susca et al., 2011). Thus, the built environment can have a substantial impact on temperatures. For example, urban areas, which are prone to urban heat islands, are more likely to house low-income and minority populations, who may not be able to afford air-conditioning, or may be reluctant to open windows due to the presence of local crime (Lin et al., 2009). The level of acclimatization may also be impacted by regional location (Bishop-Williams et al., 2015; Knowlton et al., 2009; Lin et al., 2009). Thus, a variety of factors determines increases in hospitalizations and visits to emergency department during EHEs.

Further research in this topic is crucial as climate change is expected to financially impact health care systems, and thus work needs to be done to assess what these costs are and how they can be minimized (Paterson et al., 2014). Furthermore, health care providers will have to be knowledgeable about how to cope with an increasing number of cases related to climate change, such as heat-related illnesses (Paterson et al., 2014).

4.2.2 Impacts of Extreme Heat Events on Air Quality

Although there is evidence that heat can affect air quality, the relationship that air pollution has on heat-mortality is still debated (Bustinza et al., 2013; Harlan & Ruddell, 2011; Knowlton et al., 2009). As different pollutants impact human health in different ways, the relationship between air pollutants on human health is complex (Harlan & Ruddell, 2011). However, research has shown that warmer temperatures impacts air pollution, which then has negative impacts on human health (Harlan & Ruddell, 2011). Furthermore, it is clearly evident that air pollutants, on their own, can have a negative impact on human health, and these impacts are expected to worsen with climate change, specifically in urban regions (Harlan & Ruddell, 2011). The financial cost of air pollution on human health is also high, which is another reason it is an important issue to address (Watts et al., 2015). For example, one report estimated that in 2015, the welfare cost of PM2.5 and ground-level ozone in Canada was $36 billion (International Institute for Sustainable Development, 2017). This estimate was based on premature deaths and illness caused by these pollutants (International Institute for Sustainable Development, 2017).

The poor, socially isolated, ethnic minorities as well as the elderly and very young are among those who are especially vulnerable to air pollution (Harlan & Ruddell, 2011). For example, research has highlighted that exposure to pollutants can lead to an increased risk of asthma among children (Lavigne, Villeneuve, & Cakmak, 2012). Those aged 75 and over are at risk of other illnesses such as stroke (Chen et al., 2014). Individuals with existing illnesses are also vulnerable to poor air quality (Harlan & Ruddell, 2011; To et al., 2015). For example, one study highlighted that individuals in Ontario living with one of eleven chronic diseases showed an increased use in health services after exposure to air pollution, which was measured using the Air Quality Health Index (AQHI) (To et al., 2015). Hospital admission and outpatient visits were primarily impacted, rather than emergency department admissions (To et al., 2015). Increased usage of health service continued for one day after the peak in AQHI was reached (To et al., 2015). Like extreme heat, a variety of factors also affects the negative health consequences associated with poor air quality.

Levels of air pollutants also vary by season (Chen et al., 2014; To et al., 2015). Research has found average levels of Carbon Monoxide (CO), Nitrogen Dioxide (NO_2) and Sulfur Dioxide (SO_2) were higher in the cold season, while Ozone (O_3), Fine Particulate Matter ($PM_{2.5}$) and Particulate Matter (PM_{10}) were

higher in the warm season (Chen et al., 2014). But concern for air pollutants remain regardless of these generalizations. For example, when assessing the impact of air pollutants in Edmonton, researchers used AQHI data from 1998 to 2002 to reveal that certain pollutants, including NO_2 and CO, showed a statistically significant association with emergency department visits for acute ischemic stroke during the warm season, as categorized by April to September (Chen et al., 2014). Another study in Windsor revealed an increase in the risk of emergency department visits for asthma during the spring and summer among those exposed to SO_2, NO_2 and CO (Lavigne et al., 2012).

There are also stronger statistically significant associations between poor air quality and negative health outcomes with increased exposure time (Chen et al., 2014). Exposure time is important to consider, as research shows that Canadians spend more time outdoors during warm seasons (Chen et al., 2014). Geographic region also influences levels of air pollutants. For example, one study assessed the impact of short-term air pollution on health service use by those with chronic disease (To et al., 2015). Research revealed that the highest average AQHI and levels of NO_2 were found in the most populous and smallest Local Health Integration Network in Ontario (To et al., 2015).

By focusing on Hamilton, this study will provide additional insights about the health impacts of heat events. This study will provide a better understanding of the impacts to health systems, as well as the health of individual Canadians. By assessing air quality, this project will also provide a current picture of the relationship between heat events and air quality, giving further insight into health impacts. In addition, focusing on certain FSAs may provide information about potential health disparities among different neighbourhoods in Hamilton.

4.3 Methods

4.3.1 Study location:

This study took place in Hamilton, Ontario (Figure 1). The city is divided by the Niagara Escarpment, and the lower city has a higher proportion of individuals with lower socioeconomic status, while those in the upper city are typically wealthier (Radisic et al., 2016). This physical divide may be a contributing factor to the poor air quality in the lower city, along with other factors such as vehicle traffic and the presence of industry located in the north end of the city and along the harbour (Radisic et al., 2016).

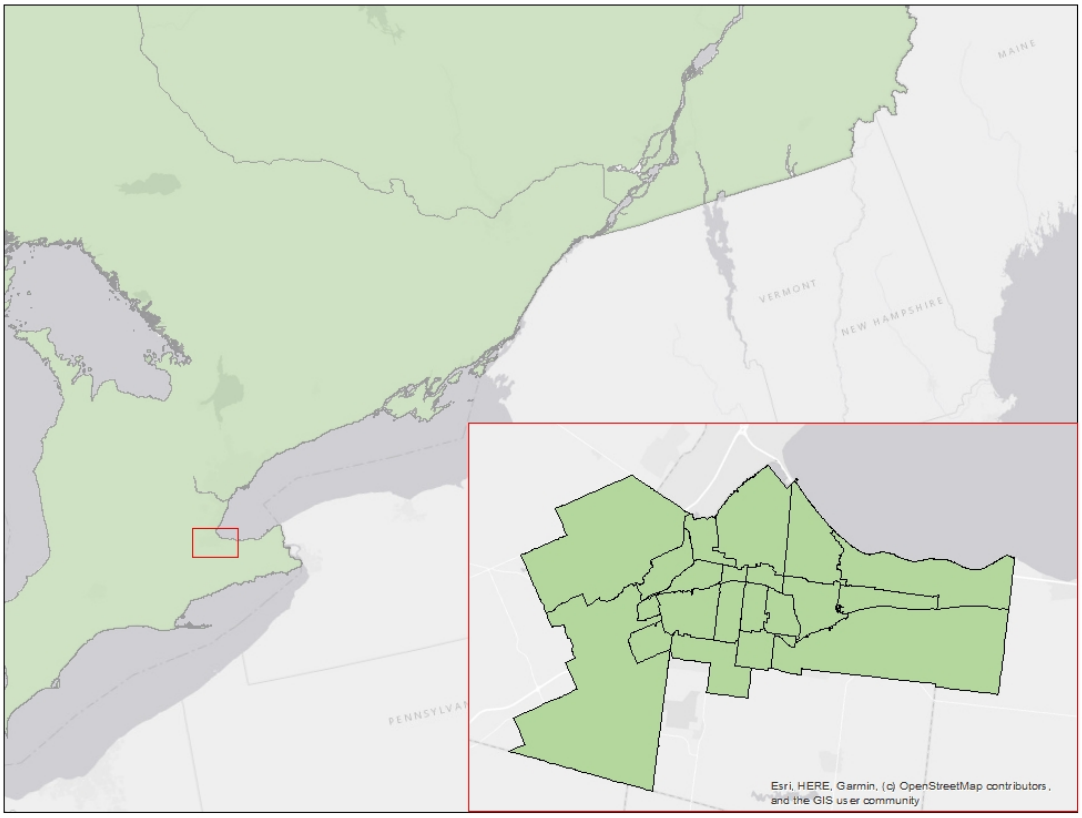

Figure 1: Study area, Hamilton Ontario (City of Hamilton, 2018; Statistics Canada, 2019).

4.3.2 Analysis

Focusing on the summer months, hospital data was retrieved from the Canadian Institute for Health Information (CIHI). Two databases were requested, the Discharge Abstract Database (DAD), and the National Ambulatory Care Reporting System (NACRS). The DAD included all acute care records with a diagnosis of heat related illnesses for admission dates between May 1st and October 31st of 2016, 2017 and 2018. The DAD included the province, facility name, fiscal year, FSA, age code, age unit, gender, admission date and diagnosis code. The NACRS database included all emergency department visits with a diagnosis of a heat related illness, and a registration date between May 1st and October 31st of 2016, 2017 and 2018. Fields in the NACRS database included the province, fiscal year, FSA, gender code, age number age unit, date of registration, admitted via ambulance, diagnosis code, and ED presenting complaint code[1]. Only residents of Hamilton and hospitals in Hamilton were included in both databases.

The hospitals in the databases included the McMaster Children's Hospital, Hamilton General Hospital, Juravinski Hospital and St. Joseph's Healthcare Hamilton. Heat related illnesses included: Acute

[1] This is the complaint of the patient, many of these can be associated with and ICD-10 code.

Coronary Syndrome, Cardiac Arrest, Stroke, Asthma, Renal Failure, Heat Stroke, Heat Exhaustion, Heat Fainting, Heat Cramps and Heat Edema. These were chosen based on illnesses directly and indirectly related to heat, as identified by Health Canada, as well as similar research (Lavigne et al., 2012; Lin et al., 2009; Soneja et al., 2016). Illnesses were recorded under the Canadian modification of the International Classification of Diseases, ICD-10-CA.

Poisson regression was used to determine how the total number of daily heat-related incidents, whether through an inpatient case or emergency department visit, was impacted by Maximum Temperature, AQHI, heat event, gender, age, year, and FSA. Main effects (maximum temperature, AQHI, heat events, gender age, and year) were forced into the model, with stepwise-regression analysis used to select only those FSAs that had significantly higher (lower) admissions relative to the city overall. Separate regressions were run for individual years as well as one regression that incorporated all three years, with a dummy variable capturing the effect of the individual years. All analysis was carried out using SAS.

Hospital admissions for cardiovascular and respiratory illnesses have also been associated with summer temperatures. Calkins et al. (2016), for example, noted that one degree above temperature thresholds led to a statistically significant effect on same day or lagged admissions (Calkins et al., 2016). In the current paper, daily maximum temperature (without humidity) was retrieved for May 1st to October 31st of 2016, 2017 and 2018. Temperature data was retrieved from the federal government's open historical data via Environment and Climate Change Canada. Missing values were captured by taking an average of the maximum temperature from the day before and the day after. The daily Air Quality Health Index (AQHI) was retrieved from open data available from the province of Ontario via the Ministry of Environment, Conservation and Parks. Daily AQHI data was obtained for May 1st to October 31st of 2016, 2017 and 2018. Missing values were captured by taking an average of the AQHI value from the day before and day after. The AQHI includes measures NO_2, O_3 and $PM_{2.5}$ to assess air quality (Ministry of the Environment, Conservation and Parks, n.d.)

While temperature has been associated with cardiovascular and respiratory health admissions, admissions have also been observed to increase in conditions of extreme heat events. For the period included in this study, Hamilton had three heat response levels. The first level, "Heat Advisory", was declared when there was "one day with forecasted temperature greater than or equal to 31° and humidex of 40° or greater" (A. Wilson, personal communication, June 18, 2020)."The second level, "Heat Warning", was declared when there were two or more consecutive days forecasted with daytime highs greater than or equal to 31°C and nighttime lows greater than or equal to 20°C ***or*** a humidex of 40°C or greater (City of Hamilton, 2020)." The highest level of response is the "Extended Heat Warning", initiated when there are

"three or more consecutive days observed with daytime highs greater than or equal to 31°C and nighttime lows greater than or equal to 20°C ***or*** a humidex of 40°C or greater" (City of Hamilton, 2020)."

In this paper, heat events were captured by a dummy variable, with "1" assigned to days that were considered a heat event, and a "0" to a non-heat event. A day was assigned as a heat event if it was declared as a Heat Advisory, Heat Warning or Extended Heat Warning by the City of Hamilton. A 3-day buffer was also added after each heat event, as health impacts from heat events may only be seen after the actual event (Bustinza et al., 2013; Pillai et al., 2014). An AQHI event was defined as a day with an AQHI value of 4 or more. We chose to define an AQHI event this way because a value of 3 or less indicates a low health risk (Ministry of the Environment, Conservation and Parks , n.d.). Similar to other studies(Parry et al., 2019; Sherbakov et al., 2018; Soneja et al., 2016), age was also coded so that any individuals ages 65 and older were assigned a "1", and anything below was assigned a "0". Given there may be geographical variation in the use of ER and hospitals, with some areas of the city characterized by more vulnerable populations, dummy variables for FSAs were included in the regression analysis.

Age and gender are the only sociodemographic variables included in the NACRS and DAD databases. With respect to gender, the literature notes mixed results, with one study that assessed heat health impacts showing no differences in admission rates among males and females (van Loenhout et al., 2018), while another study conducted in Pennsylvania that assessed how heat impacted the risk of hospitalizations for stroke, highlighting that men were at greater risk to heat-health consequences (Ha et al., 2014). Age, defined in the current study as either greater or less than 65 years, has been associated with hospital admissions during heat events. Looking at EMS calls during heat events, there was a statistically significant increase in calls on heat days in comparison to non-heat days for all ages (Yardley et al., 2011). Other research has shown specific impacts on the elderly (Ha et al., 2014), or younger populations (Soneja et al., 2016). This range in results may be due to a variety of reasons. Researchers noted that those ages 75 and older may be isolated, have limited access to care, or may believe they are not vulnerable, impacting the expected number of elderly in emergency departments during heat waves (Davis & Novicoff, 2018). One study also highlighted that cases of cardiovascular disease during heat waves may result in death before individuals are able to seek care (Parry et al., 2019). Conversely, younger individuals may have certain vulnerabilities because they spend more time outdoors doing physical activity (Parry et al., 2019), which may also be a result of employment (Davis & Novicoff, 2018).

FSAs were also considered because even within a small geographic area, there can be variations based on proximity to built and natural features. As noted in the literature review, existing research highlights that heat health vulnerability may exist due to geographic variability (Knowlton et al., 2009). However, not all health regions assessed in a Quebec study had statistically significant increases in

admissions to emergency departments (Bustinza et al., 2013). In this study, FSAs in Hamilton with higher levels of immigrants, newcomers (arrivals from 2011-2016), and elderly were the primary focus, as determined by 2016 census data. These included the following 16 FSAs: L8N, L8R, L8S, L8E, L9A, L9K, L8W, L9C, L9B, L8G, L8P, L9H, L8V, L8T, L8K, L9G.

4.4 Results

In total, there were 15 heat events from 2016 to 2018. However, when heat warnings are separated from events that turned into extended heat warnings, there was a total of 19 events (Table 1). With the DAD and NACRS data combined, there were more individuals who were 65 years and older (Table 2). There were also more males than females (Table 2). Over the period of study, there were 173 AQHI "events" (Table 3).

Three FSAs, L8L, L8K and L9C in Hamilton had higher rates of heat-related illnesses (Figure 2). Each of these are located in different parts of the city. Reasons for this variation are not clear. Surprisingly, although the industrial area has a high rate of heat-related illnesses, it is not the highest. These FSAs were also not statistically significant, as will be discussed later in this section.

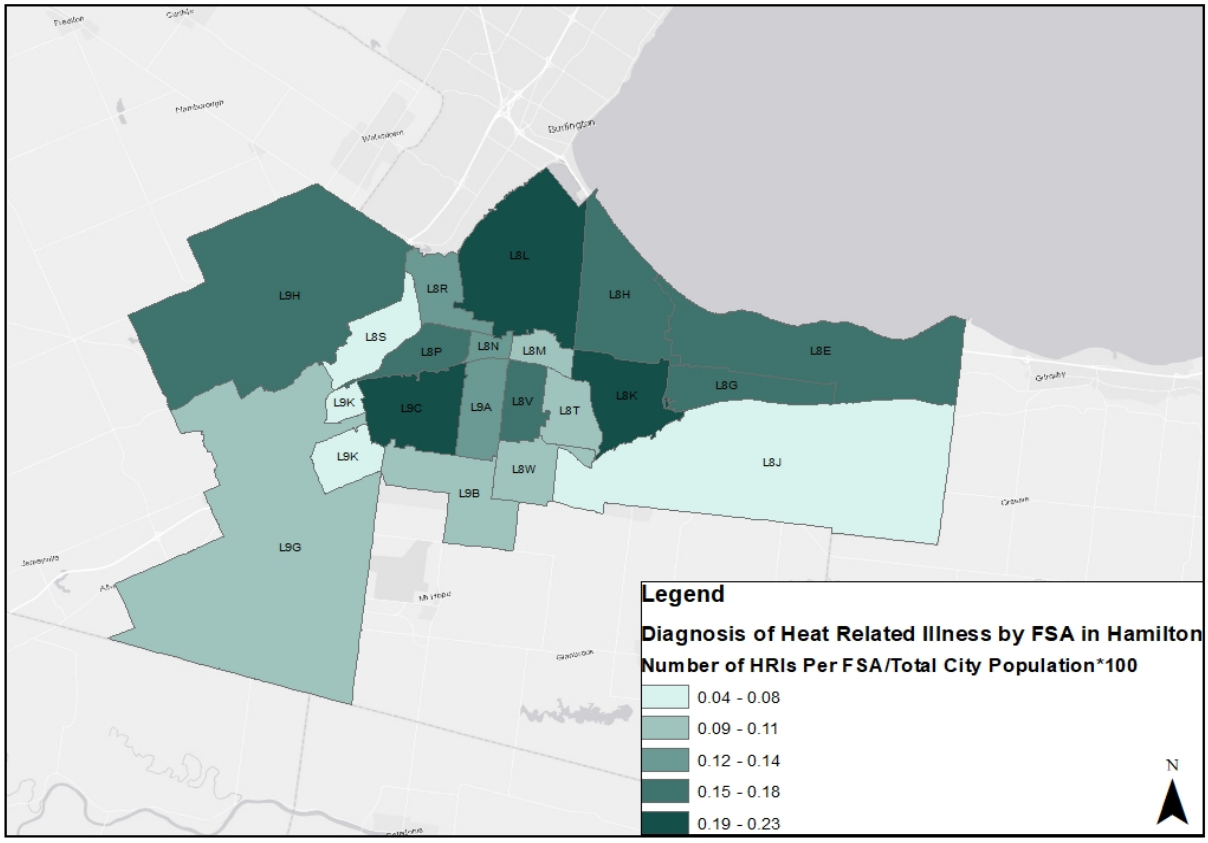

Figure 2: Heat related illnesses by Forward Sortation Area (FSA) in Hamilton (Statistics Canada, 2019).

Table 1: Quantification of EHEs

Year	Number of Heat Advisories	Number of Heat Warnings	Extended Heat Warnings	Average Duration (days)- Without buffer	Minimum Duration (days)- Without buffer	Maximum Duration (days)- Without buffer
2016	1	6	3	3.71	1	6
2017	0	2	0	4	3	5
2018	0	6	1	4.16	3	8

Table 2: Summary of admissions by age and sex

Category	Total Admissions
Age (less than 65 years) 65 years and older Females Males	4773 9920 6950 7743

Table 3: Summary of AQHI events

Category	**Total**
Days with an AQHI Event (Daily reading of AQHI 4 and over)	173
Days without an AQHI Event	379

Equations were estimated for each of the individual years as well as all three years. Similar relationships were noted in the analysis, although there were some subtle differences in the results (Table 4). For example, AQHI was negative and significant in 2018, but positive in 2016 (significant) and 2017 (insignificant). Maximum temperature was only negative in 2018. Heat event was also not significant in 2016.

Table 4: Analysis of factors that influence increase in admissions and emergency department visits for heat related illnesses.

Year	2016		2017		2018		**All**	
Intercept	3.18	<.0001	3.15	<.0001	3.43	<.0001	**3.318**	**<0.0001**
AQHI Event	0.015	0.0181	0.004	0.5152	-0.012	0.0476	**0.007**	**0.0567**
Max Temp	0.0053	<.0001	0.0065	<.0001	-0.0025	<.0001	**0.002**	**<0.0001**
Heat Event	0.012	0.1038	0.083	<.0001	0.035	<.0001	**0.04**	**<0.0001**
65 years and older	0.005	0.4087	-0.0065	0.2760	0.0018	0.7404	**0.0002**	**0.9505**
Female	-0.0016	0.7770	0.003	0.5851	-0.0059	0.2644	**-0.0024**	**0.4407**
2016							**-0.06**	**<0.0001**
2017							**-0.064**	**<0.0001**
L8E					0.035	0.0016	**0.021**	**0.0009**
L8W			0.03	0.0316			**0.017**	**0.0404**
N	4847		4774		5072		**14693**	
AIC	30471		29847		34257		**9490631**	

When comparing between 2016, 2017, 2018 and all years, the most variables were generally consistent. For example, maximum temperature was significant at 5% and positive, except for in 2018 when it was negative. Heat event was also positive in all four cases, and only insignificant in 2016. Age was always insignificant, but only negative in 2017. Finally, gender was always insignificant and only positive in 2017 (Table 4).

Focusing on the final two columns in Table 4 (all years), AQHI, maximum temperature and heat events all significantly increase the likelihood of admission. However, neither age nor gender were statistically significant. The dummy variables controlling for year reveal that admissions were less likely in

2016 and 2017 as compared to 2018. Two Forward Sortation Areas were also statistically significant and associated with increased likelihood of admission.

When looking at the heat event with a three-day buffer, there is an increase in admissions during a heat event versus a non-heat event, when all the other variables in the model are held constant. This is similar to other studies. Quebec, a heatwave in 2010 led to an increase in ED admission by 4 percent, but the daily variations were minimal (Bustinza et al., 2013). Another study showed an increase in the risk of respiratory and potential heat-related diseases during increases in temperatures during the summer season (van Loenhout et al., 2018).

This is the same for AQHI, which showed an increase in admissions for a day with an AQHI event verses a day with a non-AQHI event. Other studies have showed mixed results. One study conducted in Windsor used NACRS data to assess ED visit for asthma and the short-term relationship with air pollution. The study focused on pollutants included in the AQHI (NO_2, O_3 and $PM_{2.5}$) in addition to SO_2 and CO (Lavigne et al., 2012). Researchers found a positive association but only statistically significant results subgroups SO_2, NO_2, O_3, and CO, and no statistically significant associations between ED visits for asthma and $PM_{2.5}$. Another study found that adjustment for pollutants did not impact how cardiovascular admissions were impacted by high temperatures (Lin et al., 2009).

The Maximum Temperature variable was the daily maximum temperature (without humidity). After running the model, results show that a 1 unit increase in degrees Celsius, leads to an increase in 0.002 of the log of the expected count of heat-related emergency department visits and admissions, give the other model variables are held constant.

With respect to geography, increased admissions were associated with two FSAs (L8E and L8W). When compared to the rest of the FSAs, L8W has a higher number of immigrants, while L8E has a higher rate of immigrants and recent immigrants (those arriving between 2011 and 2016). L8E is also located in an industrial area of the city. However, these FSAs did not have the highest rates of heat-related emergency department visits or admissions (Figure 2), further highlighting that geographic variation may exist, but more research is needed.

Age was not statistically significant in this study. Individual age has shown to have impacts in different ways as existing research has shown to impact the young (Soneja et al., 2016) and elderly (Ha et al., 2014; Lin et al., 2009). Although it was expected that they elderly may be more impacted, this study might not have seen such results if elderly individuals were unable to access health care or they did not consider themselves to be vulnerable to EHEs (Davis & Novicoff, 2018). Despite the larger number of cases, females were just as likely as males to be admitted to hospital. This was similar to results in another

study (van Loenhout et al., 2018), but different from results in another study that noted males to be especially vulnerable to heat health risks (Ha et al., 2014).

4.5 Discussion and Conclusion

This study assessed how heat events between 2016 and 2018 in Hamilton effect hospital admissions for heat-related illnesses. Furthermore, AQHI, maximum temperature, age, gender, year and FSA were also included in the statistical models to determine if they also affected whether an individual was admitted for a heat-related illness. AQHI, maximum temperature and the presence of a heat event were all associated with a greater likelihood of admission to hospital. However, in terms of demographic factors, neither age nor gender were statistically significant. Admissions were also less likely in 2016 and 2017 compared to 2018. Two out of sixteen FSAs included in the model were statistically significant.[2]

There were several limitations to this study. For example, an individual who went to the emergency department for a heat-related illness could also be admitted, and would be counted twice, as they would be in both the NACRS and DAD dataset. This was not accounted for when running the model. Analyzing a longer span of time may have also helped to provide results that are more reliable. Furthermore, meteorological data was only collected from one geographic point, which may also affect results. Finally, only the most severe cases were included, as only emergency department visits and hospital admissions were considered. Less severe, but still relevant cases, were not accounted for.

These results align with similar research that explores the health impacts of extreme heat events and air quality (Bustinza et al., 2013; Lavigne et al., 2012), highlighting the importance of maintaining good air quality and also working to mitigate and adapt to extreme heat, both of which are related. It is interesting that age and gender were not statistically significant, and further research is needed to determine if this may be because elderly people experience negative health consequences from heat events before seeking care at a hospital (Davis & Novicoff, 2018; Parry et al., 2019). Future research could also focus more on the geographic differences of heat health impact in Hamilton, taking a closer look at microclimates, green space and building design, all of which can impact heat health (Lubik et al., 2017; Ngom et al., 2016; Ruddell et al., 2010). This research, and similar future studies can help to justify extreme heat mitigation and adaptation strategies.

[2] Interaction effects between gender and heat events, as well as age and heat events were tested, but were not statistically significant.

References

Bishop-Williams, K. E., Berke, O., Pearl, D. L., & Kelton, D. F. (2015). A spatial analysis of heat stress related emergency room visits in rural Southern Ontario during heat waves. *BMC Emergency Medicine*, *15*(1), 1–9. https://doi.org/10.1186/s12873-015-0043-4

Bustinza, R., Lebel, G., Gosselin, P., Bélanger, D., & Chebana, F. (2013). Health impacts of the July 2010 heat wave in Québec, Canada. *BMC Public Health*, *13*(1). https://doi.org/10.1186/1471-2458-13-56

Calkins, M. M., Isaksen, T. B., Stubbs, B. A., Yost, M. G., & Fenske, R. A. (2016). Impacts of extreme heat on emergency medical service calls in King County, Washington, 2007-2012: Relative risk and time series analyses of basic and advanced life support. *Environmental Health: A Global Access Science Source*, *15*(1), 1–13. https://doi.org/10.1186/s12940-016-0109-0

Campbell, S., Remenyi, T. A., White, C. J., & Johnston, F. H. (2018). Heatwave and health impact research: A global review. *Health and Place*, *53*(August), 210–218. https://doi.org/10.1016/j.healthplace.2018.08.017

Chen, L., Villeneuve, P. J., Rowe, B. H., Liu, L., & Stieb, D. M. (2014). The Air Quality Health Index as a predictor of emergency department visits for ischemic stroke in Edmonton, Canada. *Journal of Exposure Science and Environmental Epidemiology*, *24*(4), 358–364. https://doi.org/10.1038/jes.2013.82

City of Hamilton. (2018). *Community Boundaries* . Retrieved from https://open.hamilton.ca/datasets/fdfe2c5081c5459f8aae7f1861a24b15_17

City of Hamilton. (2020, July). *Heat Warnings & Heat Relates Illness*. Retrieved from https://www.hamilton.ca/public-health/health-topics/heat-warnings-heat-related-illness

Climate Atlas. (2019). Retrieved from https://climateatlas.ca/map/canada/plus30_2060_85#lat=43.49&lng=-80.73&z=7&city=451

Davis, R. E., & Novicoff, W. M. (2018). The impact of heat waves on emergency department admissions in Charlottesville, Virginia, U.S.A. *International Journal of Environmental Research and Public Health*, *15*(7). https://doi.org/10.3390/ijerph15071436

Ha, S., Talbott, E. O., Kan, H., Prins, C. A., & Xu, X. (2014). The effects of heat stress and its effect modifiers on stroke hospitalizations in Allegheny County, Pennsylvania. *International Archives of Occupational and Environmental Health*, *87*(5), 557–565. https://doi.org/10.1007/s00420-013-0897-2

Hamilton Immigration Partnership Council (Instituation/Organization). (2019). *A demographic profile of immigrants in Hamilton* (Issue March).

Harlan, S. L., & Ruddell, D. M. (2011). Climate change and health in cities: Impacts of heat and air pollution and potential co-benefits from mitigation and adaptation. *Current Opinion in Environmental Sustainability*, *3*(3), 126–134. https://doi.org/10.1016/j.cosust.2011.01.001

Health Canada. (2011). *Communicating the health risks of extreme heat events: Toolkit for public health and emergency management officials*.

Howard, C., Caren, R., & Rivers, N. (2018). *Lancet Countdown 2018 Report : Briefing for Canadian Policymakers* (Issue November). https://dighr.yorku.ca/files/2019/03/Canadian-Countdown-Brief-2018.pdf?x44472

International Institute for Sustainable Development. (2017). *Costs of Pollution in Canada.* Retrieved from https://www.iisd.org/sites/default/files/publications/costs-of-pollution-in-canada.pdf

Knowlton, K., Rotkin-Ellman, M., King, G., Margolis, H. G., Smith, D., Solomon, G., Trent, R., & English, P. (2009). The 2006 California heat wave: Impacts on hospitalizations and emergency department visits. *Environmental Health Perspectives*, *117*(1), 61–67. https://doi.org/10.1289/ehp.11594

Lavigne, E., Villeneuve, P. J., & Cakmak, S. (2012). Air pollution and emergency department visits for asthma in Windsor, Canada. *Canadian Journal of Public Health*, *103*(1), 4–8. https://doi.org/10.1007/bf03404060

Lin, S., Luo, M., Walker, R. J., Liu, X., Hwang, S. A., & Chinery, R. (2009). Extreme high temperatures and hospital admissions for respiratory and cardiovascular diseases. *Epidemiology*, *20*(5), 738–746. https://doi.org/10.1097/EDE.0b013e3181ad5522

Lubik, A., Mckee, G., Chen, T., & Kosatsky, T. (2017). *Municipal Heat Response Planning in British Columbia*.

Ministry of the Environment, Conservation and Parks . (n.d.). *AQHI Categories and Health Messages*. Retrieved from http://www.airqualityontario.com/aqhi/health_messages.php

Ministry of the Environment, Conservation and Parks. (n.d.). *What is the Air Quality Health Index?* Retrieved from http://www.airqualityontario.com/science/aqhi_description.php

Ngom, R., Gosselin, P., & Blais, C. (2016). Reduction of disparities in access to green spaces: Their geographic insertion and recreational functions matter. *Applied Geography*, *66*, 35–51. https://doi.org/10.1016/j.apgeog.2015.11.008

Parry, M., Green, D., Zhang, Y., & Hayen, A. (2019). Does particulate matter modify the short-term association between heat waves and hospital admissions for cardiovascular diseases in greater Sydney, Australia? *International Journal of Environmental Research and Public Health*, *16*(18), 1–16. https://doi.org/10.3390/ijerph16183270

Pillai, S. K., Noe, R. S., Murphy, M. W., Vaidyanathan, A., Young, R., Kieszak, S., Freymann, G., Smith, W., Drenzek, C., Lewis, L., & Wolkin, A. F. (2014). Heat illness: Predictors of hospital admissions among emergency department visits - Georgia, 2002-2008. *Journal of Community Health*, *39*(1), 90–98. https://doi.org/10.1007/s10900-013-9743-4

Radisic, S., Newbold, K. B., Eyles, J., & Williams, A. (2016). Factors influencing health behaviours in response to the air quality health index: a cross-sectional study in Hamilton, Canada. *Environmental Health Review*, *59*(1), 17–29. https://doi.org/10.5864/d2016-002

Ren, C., Williams, G. M., Morawska, L., Mengersen, K., & Tong, S. (2008). Ozone modifies associations between temperature and cardiovascular mortality: Analysis of the NMMAPS data. *Occupational and Environmental Medicine*, *65*(4), 255–260. https://doi.org/10.1136/oem.2007.033878

Ruddell, D. M., Harlan, S. L., Grossman-Clarke, S., & Buyantuyev, A. (2010). Risk and exposure to

extreme heat in microclimates of Phoenix, AZ. In *Geospatial Techniques in Urban Hazard and Disaster Analysis* (pp. 179–202). Springer-Verlag Press. https://doi.org/10.1007/978-90-481-2238-7

Sherbakov, T., Malig, B., Guirguis, K., Gershunov, A., & Basu, R. (2018). Ambient temperature and added heat wave effects on hospitalizations in California from 1999 to 2009. *Environmental Research*, *160*(May 2017), 83–90. https://doi.org/10.1016/j.envres.2017.08.052

Soneja, S., Jiang, C., Fisher, J., Upperman, C. R., Mitchell, C., & Sapkota, A. (2016). Exposure to extreme heat and precipitation events associated with increased risk of hospitalization for asthma in Maryland, U.S.A. *Environmental Health: A Global Access Science Source*, *15*(1), 1–7. https://doi.org/10.1186/s12940-016-0142-z

Statistics Canada. (2019). *2016 Census-Boundary Files*. Retrieved from https://www12.statcan.gc.ca/census-recensement/2011/geo/bound-limit/bound-limit-2016-eng.cfm

Statistics Canada. (2019). *Census Profile, 2016 Census*. Retrieved from https://www12.statcan.gc.ca/census-recensement/2016/dp-pd/prof/details/page.cfm?Lang=E&Geo1=CD&Code1=3525&Geo2=PR&Code2=35&Data=Count&SearchText=hamilton&SearchType=Begins&SearchPR=01&B1=All&TABID

To, T., Feldman, L., Simatovic, J., Gershon, A. S., Dell, S., Su, J., Foty, R., & Licskai, C. (2015). Health risk of air pollution on people living with major chronic diseases: A Canadian population-based study. *BMJ Open*, *5*(9), 1–8. https://doi.org/10.1136/bmjopen-2015-009075

van Loenhout, J. A. F., Delbiso, T. D., Kiriliouk, A., Rodriguez-Llanes, J. M., Segers, J., & Guha-Sapir, D. (2018). Heat and emergency room admissions in the Netherlands. *BMC Public Health*, *18*(1), 108. https://doi.org/10.1186/s12889-017-5021-1

Watts, N., Adger, W. N., & Agnolucci, P. (2015). Health and climate change: Policy responses to protect public health. *Environnement, Risques et Sante*, *14*(6), 466–468. https://doi.org/10.1016/S0140-6736(15)60854-6

Watts, Nick, Amann, M., Arnell, N., Ayeb-Karlsson, S., Belesova, K., Berry, H., Bouley, T., Boykoff, M., Byass, P., Cai, W., Campbell-Lendrum, D., Chambers, J., Daly, M., Dasandi, N., Davies, M., Depoux, A., Dominguez-Salas, P., Drummond, P., Ebi, K. L., … Costello, A. (2018). The 2018 report of the Lancet Countdown on health and climate change: shaping the health of nations for centuries to come. *The Lancet*, *392*(10163), 2479–2514. https://doi.org/10.1016/S0140-6736(18)32594-7

Yardley, J., Sigal, R. J., & Kenny, G. P. (2011). Heat health planning: The importance of social and community factors. *Global Environmental Change*, *21*(2), 670–679. https://doi.org/10.1016/j.gloenvcha.2010.11.010

Chapter 5

5.1 Introduction

This project used a mixed-methods approach to assess heat health vulnerability in Hamilton, Ontario, specifically among the immigrant and newcomer population. This thesis was divided into three main chapters. The research questions for chapter 2, the first qualitative chapter focused on barriers immigrants in Hamilton face when trying to cope with extreme heat events, the type of barriers, and whether immigrants experience adverse impacts from extreme heat events. Chapter 3 was the second qualitative chapter, and the main objective was to explore formal and informal EHE coping measures in Hamilton that are directed at the immigrant population. Finally, Chapter 4 applied quantitative methods to: explore if there is a relationship between EHEs, air quality and hospital admissions in Hamilton; and 2) Explore the geography of hospital admissions, represented by forward sortation areas (FSAs), within the city.

Current literature includes similar research looking at immigrant and newcomer heat health vulnerability in places such as Australia (Hansen et al., 2014). Research looking at hospital admissions due to heat events or poor air quality have also taken place in Canada (To et al., 2015), and more specifically Southern Ontario (Bishop-Williams et al., 2015), but have lacked a focus on Hamilton. This thesis filled part of this research gap by focusing on the impacts of EHEs on immigrant and newcomer population in Hamilton through the use of both qualitative and quantitative techniques.

5.2 Key Findings, Contributions and Knowledge Transfer

Each chapter provided results that can contribute to the gaps in current literature and help to support the work of local stakeholders in Hamilton. The second chapter used intersectionality to highlight factors that contribute to heat health vulnerability among immigrants and newcomers in Hamilton. Findings included factors commonly noted in literature, such as language, culture, and age. However, this chapter expanded on current findings by using intersectionality to note how vulnerabilities are dynamic and can change at different points of an individual's life. For example, children may be expected to provide leadership in the family, while parents are forced to rely on them in ways they had not, previously to immigrating. This also interacts with culture, gender, and age. This chapter also noted the importance of technological literacy in reducing vulnerability to EHEs. Often, older individuals may lack the necessary skills to use technology, potentially hindering access to EHE alerts or information about adaptation methods. Even if individuals have high levels of technological literacy, their socioeconomic status may inhibit them from having internet access or technology, highlighting the importance of applying an intersectionality lens and looking at how multiple social locations can influence access to online EHE information.

The third chapter highlighted current adaptation efforts. Both formal and informal methods of coping mechanisms where discussed as well as the impacts of EHEs on long-term strategies. The chapter provides a needed analysis of existing efforts in Hamilton, highlighting gaps in current strategies. Using risk perception to frame the results also provided exposure to how extreme heat events are viewed among service providers and those they assist. Results indicated the importance of having a variety of formal and informal methods, and highlighted the importance of social networks, various avenues for information dissemination as well as both private and public cooling spaces. Findings also noted that while current efforts are important in reducing vulnerability to EHEs among the immigrant and newcomer population, more work could be done. Strategies should take on a comprehensive approach and include long-term thinking. Including community stakeholders in planning adaptation efforts may help to ensure comprehensive strategies. Service providers should also be better equipped to understand the health hazards associated with the EHEs, and aware of adaptation efforts. This would require financial and educational resources.

The fourth chapter concluded that AQHI, maximum temperature and the presence of a heat event were all associated with a greater likelihood of admission to hospital for a heat-related illness. This provided a necessary quantitative analysis of the impact of EHEs in Hamilton. Demographic factors, age and gender, were not statistically significant. Admissions were also more likely in 2018, compared to 2016 and 2017. Looking at FSAs also provided an overview of geographic differences throughout the city, and although only two FSAs were statistically significant, this was still important to do considering Hamilton's history with spatial differences of environmental issues. By providing a quantitative overview of the impacts of EHEs on health in Hamilton, this chapter contributed to current literature and provides a solid foundation for future work.

The results of this study will be summarized into a research brief for participants. Furthermore, the results may be presented at the 2021 annual meeting of the American Association of Geographers or similar meeting. Results will also be shared with Health Canada's Climate Change and Innovation Bureau.

5.3 Limitations

There were several limitations to this study. For example, immigrants and newcomers were not interviewed, limiting the perspectives included in this project. Intersectionality was also used to frame the results and discussion of chapter two; however, the research questions were not made with an intersectional focus in mind, and this theory should have framed the study from the very beginning. Results in Chapter 2 also did not mention the importance of employment conditions – an area that has generally been overlooked within the literature associated with vulnerability to heat events. This could be an area for future research. Interviews for the qualitative portion of the project were also done several months before the start of the

Covid-19 pandemic. Future research should also consider how heat adaptation strategies could evolve to include physical distancing measures. In chapter four, some patients could have been included in both the DAD and NACRS dataset, and this was not adjusted for in the model. Conducting statistical analysis for a longer period might have also given results that are more robust. Furthermore, meteorological data was only collected from one geographic point, limiting the analysis if the data varied spatially. Information about at-risk populations were based on data at the FSA scale from Statistics Canada, not on individual patient data. For the purposes of this project, FSAs are a large geographic are, and having individualized data would provide results that are more informative. Finally, as only hospital emergency department visits and admissions were included, this may have excluded many people who suffered from heat-related illnesses yet did not go to the hospital.

5.4 Future Research Directions

There are many ways to expand on this research. Interviewing immigrants and newcomers is crucial for future work. Furthermore, using Participatory Action Research methods for future research projects related to EHEs and climate change is important to ensure the research is relevant to those it is supposed to benefit the most. Similar projects could be done in other Canadian cities with higher proportions of newcomers and immigrants. The intersectional focus could also be expanded to include immigrants and newcomers with disabilities. There is also a need for more detailed evaluations of specific EHE adaptation programs in Hamilton to determine how effective they are. Future research could also look at the impacts of employment conditions on heat-health vulnerability among immigrants and newcomers. Furthermore, the quantitative work could be expanded to focus on smaller geographic scales by focusing on microclimates throughout Hamilton.

References

Bishop-Williams, K. E., Berke, O., Pearl, D. L., & Kelton, D. F. (2015). A spatial analysis of heat stress related emergency room visits in rural Southern Ontario during heat waves. *BMC Emergency Medicine*, *15*(1), 1–9. https://doi.org/10.1186/s12873-015-0043-4

Hansen, A., Nitschke, M., Saniotis, A., Benson, J., Tan, Y., Smyth, V., Wilson, L., Han, G. S., Mwanri, L., & Bi, P. (2014). Extreme heat and cultural and linguistic minorities in Australia: Perceptions of stakeholders. *BMC Public Health*, *14*(1). https://doi.org/10.1186/1471-2458-14-550

To, T., Feldman, L., Simatovic, J., Gershon, A. S., Dell, S., Su, J., Foty, R., & Licskai, C. (2015). Health risk of air pollution on people living with major chronic diseases: A Canadian population-based study. *BMJ Open*, *5*(9), 1–8. https://doi.org/10.1136/bmjopen-2015-009075

Appendix A

Interview Guide-Interviews with service providers

General questions for the employee

1) Are you aware of what an extreme heat event is?

    a) If not, define it for them

2) Are you aware of what the air quality health index is?

    a) If not, define it for them

3) Are you aware of the negative (health?) impacts from extreme heat events?

Questions related to housing

1) What services does your organization provide?

2) Does your organization provide services specifically for the newcomer population?

    a) If so, what services?

b) Does your organization provide any specific housing initiatives for the refugee population?

Questions related to extreme heat events and immigrants

1) What type of services does your organization provide for immigrants?

2) Are your services provided towards a specific category of immigrants? (e.g. newcomers, refugees, elderly, non-English speakers, etc.)

3) Approximately how many individuals does your organization see every year?

4) Is your organization involved in providing information about extreme heat events?

    a) If yes, then please explain.

5) Does your organization provide any services to specifically address extreme heat events?

    a) If yes, then please explain these services.

6) Do you receive immigrants, who are seeking your services, and asking about extreme heat events?

7) Have you or your organization identified barriers to information that immigrants might experience during extreme heat events?

8) Have you or your organization identified barriers to care that immigrants might experience during extreme heat events?

9) Are you aware of the city's messaging and actions related to extreme heat events?

    a) In your opinion, does the messaging related to extreme heat events reach the targeted audience?

    b) Can the messaging or actions be improved? Specifically in the organization you work for?

Question for health care provider

1) Do you receive immigrants who suffer any heat-related illnesses? If yes, what types of

illnesses do they experience?

Questions that tie in intersectionality

1) Do you think an individual's age influences how they receive messages or information related to extreme heat events? If yes, then how?

2) Do you think an individual's gender influences how they receive messages or information related to extreme heat events? If yes, then how?

3) Do you think being an immigrant influences how an individual receives messages or information related to extreme heat events? If yes, then how?

4) Do you think an individual's age influences how they deal with extreme heat events? If yes, then how?

5) Do you think an individual's gender influences how they deal with extreme heat events? If yes, then how?

6) Do you think being an immigrant influences how an individual deals with extreme heat events? If yes, then how?

7) Do you think age influences an individual's vulnerability to illnesses related to extreme heat events? If so, then how?

8) Do you think gender influences an individual's vulnerability to illnesses related to extreme heat events? If so, then how?

9) Do you think being an immigrant influences your vulnerability to illnesses related to extreme heat events? If so, then how?

Questions about the participant

1) What is your role in the organization you work at?

2) How long have you been employed at that organization?

Closing questions

1) Are there any questions that you would like me to repeat?

2) Are there any answers that you would like to add to?

3) Is there anything else you would like to add?

5) Do you have any questions or concerns that I can address?