

The Mental and Physical Human Health Impacts of Residential Basement Flooding and  
Associated Financial Costs: Interviews with Households in Southern Ontario, Canada

by

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### Author's Declaration

I hereby declare that I am the sole author of this thesis. This is a true copy of the thesis, including any required final revisions, as accepted by my examiners. I understand that my thesis may be made electronically available to the public.

## Abstract

This thesis summarizes primary research conducted on the mental and physical health impacts associated with residential basement flooding and their associated financial costs (e.g. days off work, visits to health services, medication use). This thesis focuses on residential basement flooding because flooding has become the costliest of all extreme weather events in Canada, as it increases in frequency and severity. The three research questions of this thesis are:

1. What are the short-term and long-term mental and physical health impacts associated with residential basement flooding?
2. What are the attributes affecting vulnerability to identified health impacts?
3. What are the mental and physical health financial costs associated with residential basement flooding?

This author interviewed 100 residents in flood-impacted neighbourhoods in Burlington, Ontario, a city where over 3,500 homes were flooded in August 2014 (Conservation Halton, 2015). The author interviewed 58 residents, who had experienced basement flooding, in reference to health impacts realized within the first 30 days of flooding, and those realized anytime after those first 30 days. A total of 42 residents who lived in the same neighbourhood but had not experienced flooding in their home formed the control, and the author interviewed them in reference to specific health impacts realized in the last three years since flooding.

In response to the first research question, the thesis found that there were significant mental health impacts (increased worry and stress) realized both in the first 30 days of experiencing flooding and approximately three years later. This suggests that there are both short-term and long-term mental health impacts associated with residential basement flooding.

In response to the second research question, there were several attributes identified in this study that significantly correlated with higher worry and stress. These attributes included age (adults and seniors from flooded households exhibited higher worry and stress than adults and seniors in the control), water height, difficulty contacting an insurance provider, and worsening of existing health issues.

In response to the third research question, the study found that over half (56%) of flooded households that had at least one working member (n=25) took time off work, and the average time off work was seven person days per household. This is substantially higher than the average for Ontario in 2014 (<1 day), suggesting that residential basement flooding significantly affects productivity for workers. Almost half (49%) of flooded households did not have full property and casualty insurance coverage.

Additional research could build on this study through examination of medical data and health claims in flood-impacted communities to further explore financial costs resulting from the health impacts of flooding. Additional research in another community with a different socio-economic background could help to determine the breadth of applicability of the study findings.

This thesis provides insight into the real worry, stress and financial impact that flooding can cause for households. As flooding increases in frequency and severity (Insurance Bureau of Canada, 2017a), this thesis provides additional urgency and rationale to implement flood mitigation measures in Canada to secure homeowners' peace of mind and reduce financial costs that otherwise may escalate in the years to come.

**Keywords:** flood, climate change, health, mental health

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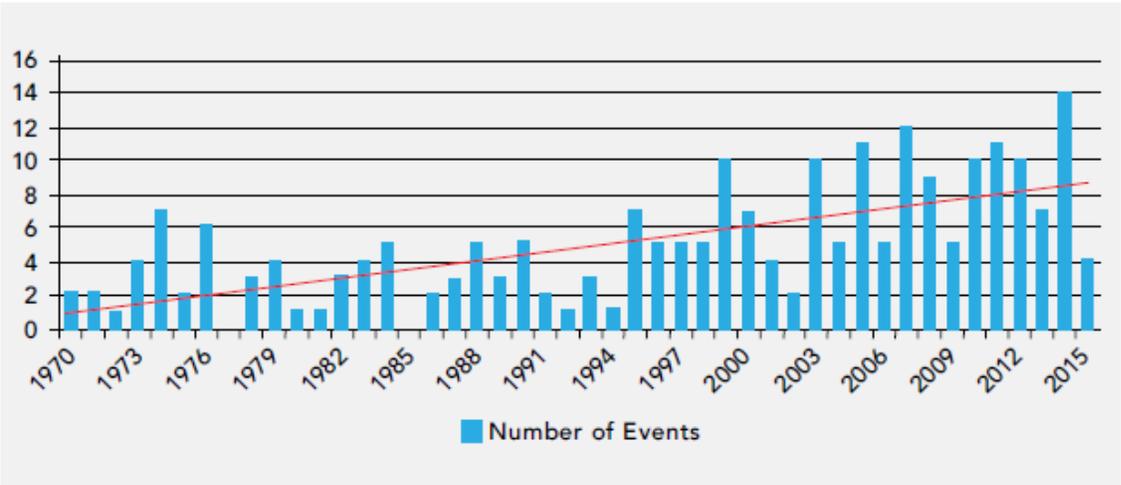
# 1.0 Introduction

*“Canadians must become better prepared for severe weather conditions as our climate continues to change” – Government of Canada (2017)*

## 1.1 Rising Costs of Extreme Weather

Extreme weather events in Canada are increasing in frequency and severity (Insurance Bureau of Canada, 2017a), and this trend is likely to continue with climate change. These events are resulting in increasing costs for governments, and by extension, all Canadians. From 2009 to 2015, federal expenditures on the Disaster Financial Assistance Arrangements (DFAA) program were more than in the previous 39 fiscal years combined (Figure 1), with the majority spent on weather-related expenditures (Auditor General of Canada, 2016).

*Figure 1: Number of Natural Disasters in Canada Requiring Disaster Financial Assistance Arrangements for Provinces and Territories (1970 to 2015)*

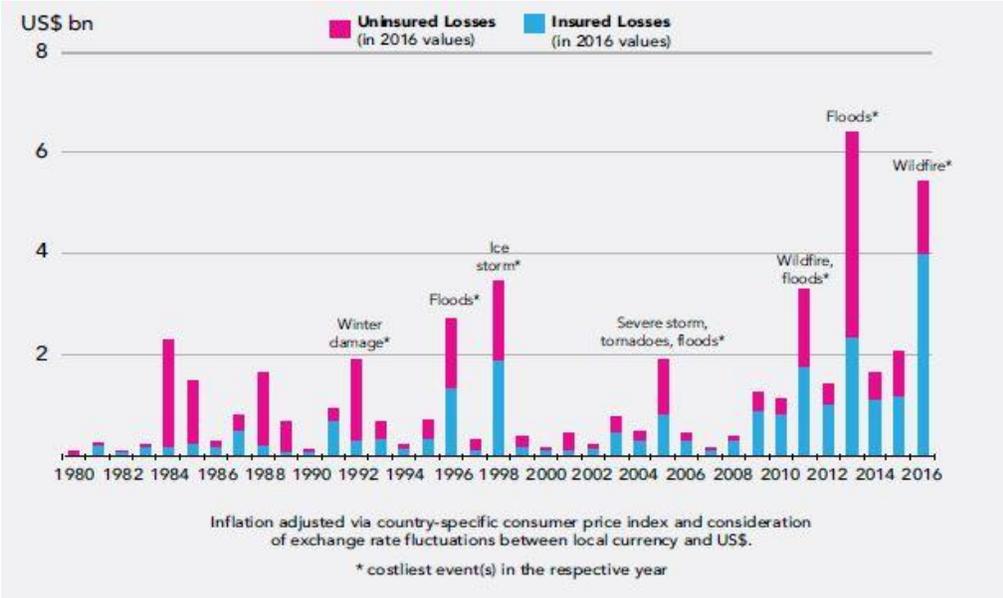


Source: Public Safety Canada, 2016-2017 Evaluation of the Disaster Financial Assistance Arrangements.

This rising cost of extreme weather events – combined with factors such as failures in built infrastructure and loss of natural infrastructure – is reflected in rising property and casualty

insurance costs in Canada. Data from the Insurance Bureau of Canada demonstrates that “property and casualty insurance payouts from extreme weather have more than doubled every five to 10 years since the 1980s” (Insurance Bureau of Canada, 2016). While insurable payouts averaged \$400 million per year over the period of 1980 to 2008, for the last eight of nine years leading up to 2017, extreme insurance payouts exceeded \$1 billion in Canada (ibid). Figure 2 demonstrates that while property and casualty insurance companies are paying a significant amount every year, the uninsurable component of risk is material.

Figure 2: Catastrophic Insured Losses in Canada (1980 –2016): Overall and Insured, 2016 US\$



Source: 2017 Munich Re, Geo Risks Research, NatCatSERVICE. As of February 2017.

The financial costs of extreme weather events can also be measured by impact on hours worked. The 2013 Alberta floods caused a net loss of 5.1 million working hours when 300,000 Albertans (13.5% of the working population) lost 7.5 million hours of work and only 134,000 people (6% of the working population) put in additional hours of work (Statistics Canada, 2013).

Of all extreme weather impacts, flooding in Canada has become the costliest. Between 2005 and 2014, 82% of DFAA payments went to Manitoba, Saskatchewan and Alberta, mostly due to

flood events (Office of the Parliamentary Budget Officer, 2016). The same report estimated that 75% of DFAA payments (\$673 million out of \$902 million) over the next several years will be due to flooding (ibid).

The growing frequency and severity of flooding in Canada has very real financial implications for homeowners. The average cost of a flooded basement in Canada is over \$40,000 (Insurance Bureau of Canada, personal communication, 2017), and yet, almost half of Canadians live paycheque to paycheque, unable to “scrape together \$2,000 if an emergency arose next month” (Canadian Payroll Association, 2016). Homeowners may be unable to afford refurbishing their flooded basements, and may have to default on paying the mortgage on their largest asset – their home – if they cannot afford to clean up their flooded basements. This is particularly relevant for households that experience repeat basement flooding – they may be able to afford refurbishment of their basement and continuing mortgage payments the first time a flood hits, but they are unlikely to have the means to do so a second time without defaulting on their mortgage.

## 1.2 Growing Health Impacts from Extreme Weather and Flooding

*“Climate change is the biggest global health threat of the 21st century”*

- *The Lancet, 2009*

While there are substantial financial costs resulting from flooding damages paid by the property and casualty insurance sector, there is an additional perspective for consideration – the financial implications of the mental and physical health impacts associated with residential basement flooding. Global refereed literature has identified that there are considerable physical and mental health impacts associated with all types of flooding. There are various ways to categorize these impacts – they may be physical or mental, direct (primary) or indirect (secondary) and may occur in the short and/or long-term (long-term is defined as longer than at least one year<sup>1</sup>). Direct impacts can include death, physical injury and illnesses, and indirect impacts can include water-borne illnesses, undernutrition, cardiovascular diseases, respiratory diseases, and mental health impacts (Watts et al., 2015). These impacts are outlined in Table 1 and explored in the literature review (Section 2). Table 1 lists primary and secondary impacts from all types of flooding – fluvial, pluvial and coastal<sup>2</sup>. However, the full extent of these impacts and their financial costs in Canada has been subject to limited research.

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<sup>1</sup> Lamond, Joseph & Proverbs, 2006; Tunstall, Tapsell, Green, Floyd & George, 2006.

<sup>2</sup> Fluvial (riverine) flooding occurs when rivers overflow onto the land; pluvial (surface) flooding occurs when water goes overland from a severe rain event and overwhelms the ability of the land surface to absorb the water, and coastal flooding occurs when water comes onto land from a large body of water, such as during a storm surge.

Table 1: Primary and Secondary Health Impacts from Flooding

Primary Health Impacts from Floods	
Impact	Cause
Mortality	Drowning or acute trauma (e.g. debris or building collapse) (Acharya et al., 2007; Fundter et al., 2008; Jonkman et al., 2009), usually attributable to motor vehicle accidents or inappropriate behavior in flooded areas (e.g. swimming, surfing) (Haines et al., 2006; English et al., 2009; Du et al., 2010; Fitzgerald et al., 2010)
Shock, hypothermia	Exposure to floodwater which is often below human core body temperature (Acharya et al., 2007; Carroll et al., 2010; Du et al., 2010)
High blood pressure, heart attacks and strokes	Exertion and stress related to the event (Acharya et al., 2007; Jonkman et al., 2009; Carroll et al., 2010; Du et al., 2010)
Physical injuries such as lacerations, skin irritations, bruises, wound infections	Direct contact with flood water (Acharya et al., 2007; Fundter et al., 2008; Carroll et al., 2010; Du et al., 2010)
Infection, pulmonary swelling, lung irritation, fungal infection	Aspiration of water into lungs (Robinson et al., 2011)
Sprains, strains and orthopedic injuries	Contact with water-borne debris, attempts to escape from collapsed structures, falls from ladders, attempts to rescue people or possessions, etc. (Acharya et al., 2007; Fundter et al., 2008; Carroll et al., 2010; Du et al., 2010)
Electrical injuries	Contact with downed power cables/lines, circuits and electrical equipment in contact with standing water (Du et al., 2010)
Burns (fire-related or chemical) and explosion-related injuries	Disturbed propane and natural gas lines, tanks, power lines and chemical storage tanks; toxic gas emissions; rescue boats coming in to contact with power lines (Du et al., 2010)
Secondary Health Impacts from Floods	
Impact	Cause
Exacerbation of existing illnesses, including chronic diseases	Disruption/decreased availability of emergency and ongoing health services, especially if health infrastructure is affected, including: decreased ability to provide/access care; displacement of patients and staff; impaired surveillance of illness, injury, toxic exposure; loss of medical records; loss/impairment of medication and medical devices (Haines et al., 2006; Du et al., 2010; Ebi and Paulson, 2010)
Carbon monoxide poisoning	Inappropriate use of unventilated cooking tanks (e.g. barbeques), pressure washers and gas powered generators (Du et al., 2010)
Burns/smoke inhalation	House fires started by candles (Du et al., 2010)
Dehydration, heat stroke, heart attack, stroke	Exposure of vulnerable populations to environmental stresses in days following event (Jonkman et al., 2009)
Water- and food-borne diseases – upset stomach/gastrointestinal problems, infectious diseases with longer incubation periods including <i>Legionella pneumophila</i> (Marcheggiani et al., 2010) <i>Norovirus</i> , <i>Rotavirus</i> , <i>Hepatitis A</i> and <i>C</i>	Water and food contamination (e.g. from sewage overflows, flooding of agricultural areas and transport of sediment, fertilizers, pesticides, etc., leakage from tanks holding petroleum products, landfill materials)(Haines et al., 2006; Acharya et al., 2007; Du et al., 2010; Ebi and Paulson 2010; Ostry et al., 2010; ten Veldhuis et al., 2010), chemical contamination of water (e.g. from flooding of industrial sites) (Du et al., 2010)
Respiratory problems/symptoms	Respiratory contaminants from mold <sup>2</sup> , bacteria <sup>3</sup> , fungal growth on damp structures (Carroll et al., 2010; Du et al., 2010; Robinson et al., 2011; Taylor et al., 2011). Also, due to <i>Legionella</i> , <i>Chlamydia</i> , <i>pneumonia</i> , <i>Burkholderia cepacia</i> , and <i>Mycobacterium avium</i> (Taylor et al., 2011)

Source: Government of Canada, 2014

### 1.3 Research Purpose and Objectives

This thesis has three research questions.

1. What are the short-term and long-term mental and physical health impacts associated with residential basement flooding?
2. What are the attributes affecting vulnerability to identified health impacts?
3. What are the mental and physical health financial costs associated with residential basement flooding?

The objectives of the thesis were to:

- Conduct a literature review to understand potential health impacts from flooding (fluvial, pluvial and coastal) and attributes that affect the vulnerability of a population to flooding,
- Identify any mental and physical health impacts from residential basement flooding, and attributes affecting vulnerability, and associated financial costs (through interviews in a southern Ontario location that has experienced residential basement flooding)

Section 2 outlines the Literature Review on physical and mental health impacts of flooding globally and their associated costs. Section 3 profiles the research method, Section 4 outlines details about the respondents, Section 5 presents results, and Section 6 discusses the results and their implications.

### 1.4 Contributions

This research contributes to the existing literature on the health impacts of flooding, and the health impacts of climate change more broadly, by addressing research gaps noted in the literature review in Section 2.0. These contributions from a research design perspective include:

- using a control (to compare health impacts between flooded households and non-flooded households from the same neighbourhoods, thus identifying which impacts were likely to be influenced by flooding),
- analyzing long-term health impacts (most research on the health impacts of flooding globally focuses on short-term impacts less than one year after a flood event), and
- conducting the research in Canada where there is limited research to date on the health impacts of residential basement flooding

Federal, provincial and municipal governments may benefit from this thesis as it provides added rationale and urgency to address flood risk. Governments of all levels can use this information to garner political support for climate adaptation, as research has found that “talking about the health impacts of climate change resonates across the political spectrum” (American Psychological Association and EcoAmerica, 2017). Surveys with Ontarians has found that “reframing the impact of climate change from an environmental to a public health issue” can be key “to increase public engagement in adaptive and mitigative behaviour change” (Cardwell and Elliott, 2013, p.1).

## 2.0 Literature Review

This section summarizes the methods, findings and discussions of a literature review on the health impacts of pluvial, fluvial and coastal flooding globally and associated financial costs.

### 2.1 Methods of Literature Review

The literature review was completed in an electronic search for the years 1996-2018 in PubMed Central, Scopus and Web of Science as well as the online public access catalogue 'Primo'.

Table 2 outlines the search terms used on these sites.

Table 2: Search Terms for Literature Review on the Health Impacts of Flooding

Health Impacts	Associated Costs
flood* AND health	flood* AND "economic analysis"
flood* AND household	flood* AND "financial" AND "health"
flood* AND health AND basement	flood* AND health in title, "income" in "Any" field
flood* AND health AND household	flood* AND health in title, "medication" in "Any" field
flood* AND psycho*	Inondation AND "santé" ( <i>French</i> )
flood* AND breath*	Inondation AND "coût" ( <i>French</i> )
Flood* AND depress*	
Flood* AND PTSD	

The majority of research found was in English, with the French terms locating only two articles: Maltais, Lachance, Fortin, Lalande, Robichaud, Fortin, & Simard (2000); and Maltais, Robichaud, & Simard (2000).

Most studies that addressed flooding and had “cost” in the title and/or abstract examined the financial cost of physical damage from flooding instead of the financial cost of health impacts. These studies were therefore excluded from the thesis.

The author identified additional literature from the bibliographies of identified articles, and by searching government sources (Environment Canada, Health Canada, Public Safety Canada, and Statistics Canada) for additional information on the flooding impacts on health and associated financial costs in a Canadian context.

Studies were included if they addressed one of the following:

- Human health impacts attributed to flooding
- Financial costs for individuals and households resulting from health impacts attributed to flooding

This search yielded approximately 160 articles that appeared relevant from their title.

The author then examined each article’s abstract and removed articles that were out of scope.

Studies were out of scope if they:

- **Only examined impacts of other natural disasters (e.g. cyclones, hurricanes) where flooding was one, but not the only, component of the disaster.** There are two reasons for this exclusion:
  - 1) health impacts could have been due in part to extensive property damage caused by severe windstorms, or other confounding factors, instead of purely flooding
  - 2) flooding that occurs from severe storms such as hurricanes or cyclones may not be comparable to more gradual flooding (Du, FitzGerald, Clark & Hou, 2010)

- **Only offered cost estimations instead of specific, documented costs.** The author excluded studies that only looked at Willingness-to-Pay (WTP), and included studies that examined actual visits to health services or increased medications.

After out of scope articles were removed, there were approximately 60 articles to include in the review.

## 2.1 Health Impacts

Globally, there are numerous documented health impacts associated with flooding, but in Canada, this topic has been barely explored. There are various methods to classify these health impacts from global studies, but generally, they can be split between direct impacts (“resulting from direct exposure to the water”) and indirect impacts (“associated with the risks associated with the damage done by the water to the natural and built environment”) (Du et al., 2010, p. 268). Impacts can happen over the immediate, medium and long-term (Ahern, Kovats, Wilkinson, Few, & Matthies, 2005; Alderman, Turner, & Tong, 2012; Du et al., 2010).

### **Direct Health Impacts**

Death from flooding happens most often where the floodwaters are flowing swiftly, as in intense flash floods or coastal storm surges and is most often caused by drowning or acute trauma (Alderman et al., 2012). The relationship between suicide and flooding is uncertain (Ahern et al., 2005; De Leo, Too, Kőlves, Milner, & Ide, 2013). Some studies have found that “communities pulling together during a natural disaster can reduce interpersonal risk factors associated with the desire for suicide” (Gordon, Bresin, Dombeck, Routledge, & Wonderlich, 2011, p.52).

Physical injuries can occur at any point after flooding when people attempt to escape the floods, collect their belongings, or attempt to clean up their homes (Alderman et al., 2012; Ahern et al., 2005; Collins, Jimenez, & Grineski, 2013; Sahni, Scott, Beliveau, Varughese, Dover, & Talbot, 2016; Tunstall, Tapsell, Green, Floyd, & George, 2006). Accidents around vehicles are very

common, resulting either from being trapped inside, or from colliding with them in the water (Du et al., 2010). Individuals can experience stiffness, sprains, bruises (Collins et al., 2013; Tunstall et al., 2006), cuts (Sahni et al., 2016) and electrocution from live wires in the basement (Du et al., 2010; Lowe, Ebi, & Forsberg, 2013). Overall, studies have found that physical injuries are one of the “leading causes of morbidity among affected residents and relief workers immediately following floods” (Alderman, 2012, p.39).

Other direct impacts include hypothermia (Du et al., 2010; Tunstall et al., 2006) and skin irritations (Ahmed, Khan, & Nisar, 2011; Alderman et al., 2012; Bich, Quang, Thanh Ha, Duc Hanh, & Guha-Sapir, 2011; Collins et al., 2013; Huang, Wang, Wu, Chen, & Huang, 2016).

### **Indirect Health Impacts**

There is a wide range of indirect health impacts associated with flooding. Physical impacts may include:

- **gastrointestinal illnesses** (Biswas, Pal & Mukhopadhyay, 1999; Huang et al., 2016; Kunii, Nakamura, Abdur, & Wakai, 2002; Reacher, McKenzie, Lane, Nichols, Kedge, Iversen et al., 2004; Zhang, Liu, Gao, Zhang, & Jiang, 2016)
- **vector-borne diseases** (World Health Organization, 2017)
- **breathing difficulties** (Ahmed et al., 2011; Biswas et al., 1999; Collins et al., 2013; Kunii et al., 2002; Milojevic, Armstrong, Hashizume, McAllister, Faruque, Yunus, et al., 2012; Tunstall et al., 2006) and
- **carbon monoxide poisoning** (Daley, Shireley, & Gilmore, 2001; Sahni et al., 2016).

There is also a range of mental health impacts, including:

- **general psychological distress** (Alderman et al., 2013; Reacher et al., 2004)
- **anxiety** (Azuma, Ikeda, Kagi, Yanagi, Hasegawa, Osawa, et al., 2014; Chae, Tong Won Kim, Rhee, & Henderson, 2005; Fernandez et al., 2015; Mason, Andrews & Upton, 2010)

- **Post-Traumatic Stress Disorder (PTSD)** (Azuma et al., 2014; Bei, Bryant, Gilson, Koh, Gibson, Komiti et al., 2013; Bokszczanin, 2007; Fernandez et al., 2015; Heo et al., 2008; Mason et al., 2010; Norris, Murphy, Baker & Perilla, 2004; Paranjothy et al., 2011; Tunstall, 2006) and
- **depression** (Bei et al., 2013; Collins et al., 2013; Dixon, Shochet, & Shakespeare-Finch, 2015; Fernandez et al., 2015; Heo et al., 2008; Lamond, Joseph, & Proverbs, 2015; Mason et al., 2010; Tunstall et al., 2006), often in combination with each other.

These are explored in greater depth below.

### **Gastrointestinal Illness**

Flooding has been known to increase the risk of gastrointestinal illness (Burton, Rabito, Danielson, & Takaro, 2016; Huang et al., 2016; Reacher et al., 2004; Wade, Sandhu, Levy, LeChevallier, Katz, & Colford, 2004; Zhang et al., 2016), particularly in locations where there is poor sanitation and hygiene (World Health Organization, 2017). Not all studies specified what gastrointestinal diseases they included, but where studies did specify, gastrointestinal illnesses included dysentery (Huang et al., 2016; Zhang et al., 2016), enterovirus infections (Huang et al., 2016), hand-foot-mouth disease (Zhang et al., 2016) and diarrhea (Wade et al., 2004; Zhang et al., 2016). One of the worst e-coli outbreaks in North America occurred in Walkerton, Ontario (2,300 people become ill and seven died) as a result of heavy rains in May 2000 that spread poorly-managed animal feces from nearby farms into a nearby well and the town's drinking water (CBC News, 2010).

Flooding that damages sewer systems or encounters fecal matter or agricultural run-off may then spread the contaminated water, increasing the health risk for individuals (Du et al., 2010; Wade et al., 2004). Studies around the world have documented an increase in gastrointestinal diseases following flooding (Biswas et al., 1999; Huang et al., 2016; Kunii et al., 2002; Wade et al., 2004;

Zhang et al., 2016). However, it can be difficult to conclusively attribute gastrointestinal illnesses to flooding, as often studies rely on self-reporting and/or it may be difficult to prove that contact with contaminated water caused by flooding resulted in the illness (Mondal, Biswas & Manna, 2001; Reacher et al., 2004). An analysis by Huang et al. (2016) of 1 million Taiwanese medical records of Taiwanese could only conclusively state that gastrointestinal illnesses “may increase with 10 days after floods receded” (p.8).

### **Vector Borne Diseases**

Because mosquitoes breed in standing water, following flood events there may be a higher risk of diseases transmitted by mosquitos, including diseases such as dengue fever, yellow fever, West Nile, and malaria (World Health Organization, 2017). A study of individuals in Romania who contracted the West Nile virus found that residents who had flooded basements were more likely to have the disease compared to residents who did not have flooded basements. This is possibly due to mosquitoes breeding in the standing water (Han, Popovici, Alexander, Laurentia, et al., 1996), but more research is needed as the relationship between precipitation and mosquito-borne disease is complex. For instance, some mosquito-borne diseases (such as West Nile Virus) can increase during drought events, for reasons still not completely understood (Wang, Minnis, Belant & Wax, 2010).

### **Breathing Difficulties**

Another indirect health impact associated with flooding can be breathing difficulties. Following flood events, studies around the world have found higher incidence of breathing difficulties (Ahmed et al., 2011; Biswas et al., 1999; Collins et al., 2013; Kunii et al., 2002; Milojevic et al., 2011; Reacher et al., 2004; Tunstall et al., 2006). Houses that have been flooded may retain moisture in the walls, which can lead to the development of mould. Mould is a known health risk factor for a wide range of breathing difficulties, including “eye, nose and throat irritation; coughing

and phlegm build-up, wheezing and shortness of breath, symptoms of asthma [and] allergic reactions” (Health Canada, 2012). Impacts have been found during or immediately after a flood (Tunstall et al., 2016) and afterwards (Milojevic et al., 2011; Tunstall et al., 2016). Homes that are undergoing renovation may place occupants particularly at risk - in a study of flooded homes in Cedar Rapids, Iowa, Hoppe et al. (2012) found that homes that were damaged and had to undergo renovations because of the flooding “had significantly higher airborne concentrations of mold, bacteria, iPM [inhalable particulate matter], endotoxin, and glucan” (p.446). This resulted in a greater incidence of self-reported allergies and wheezing as well as increased medication for breathing difficulties in the last six months after the flooding compared to the previous 12 months.

### **Carbon Monoxide Poisoning**

In the aftermath of a flood, carbon monoxide poisoning may occur when individuals use a gasoline-powered pressure washer to clean up a flooded basement (Daley et al., 2001), when they use a generator improperly (Sahni et al., 2016) or when they use a damaged boiler (Waite, Murray & Baker, 2014). Carbon monoxide is released by burning of fuels such as gasoline, and if the device is kept inside a house, the levels can reach concentration levels dangerous for human health. Individuals who experience coronary disease are the most sensitive to levels of carbon monoxide (Health Canada, 2016). Carbon monoxide poisoning from flood events may be under-reported – symptoms and death may come months after a flooding event and “may never be attributed to the flood as surveillance often ends once the floodwaters recede” (Waite et al., 2017, p.2)

### **Mental health impacts**

Flooding may be a highly stressful experience, both immediately and years afterwards – the literature has documented a wide range of mental impacts (Alderman et al., 2012). These include:

- general psychological distress (Alderman et al., 2013; Reacher et al., 2004);

- anxiety (Azuma et al., 2014; Chae et al., 2005; Fernandez et al., 2015; Mason et al., 2010)
- Post-Traumatic Stress Disorder (PTSD) (Azuma et al., 2014; Bei et al., 2013; Bokszczanin, 2007; Fernandez et al., 2015; Heo et al., 2008; Mason et al., 2010; Norris et al., 2005; Paranjothy et al., 2011; Tunstall, 2006) and
- Depression (Collins et al., 2013; Dixon et al., 2015; Fernandez et al., 2015; Ginexi & Weihs, 2000; Lamond et al., 2015; Mason et al., 2010; Tunstall et al., 2006; Waite et al., 2017)

The physical manifestations of this stress for those who have experienced flooding can include headaches, difficulty sleeping (Alderman et al., 2012; Hutton, 2004; Lamond et al., 2015) and heart palpitations (Chae et al., 2005), or all three (Chae et al., 2005; Tunstall et al., 2006). These mental impacts can also worsen existing health challenges (Alderman et al., 2012; Ginexi, Weihs, Simmens, & Hoyt, 2000; Reacher et al., 2004).

While it can be difficult to identify causation instead of simply a correlation between flood events and mental health, some studies have been able to establish a direct link thanks to surveys administered both before and after flood events (Ginexi et al., 2000; Heo et al., 2008).

Many studies have documented increased anxiety following flood events, often for months afterwards (Azuma et al., 2014; Chae et al., 2005; Fernandez et al., 2015; Malthais, Robichaud & Simard, 2000; Mason et al., 2010) or even years afterwards (Lamond et al., 2015; Tunstall et al., 2010; Waite, Chaintarli, Beck, Bone, Amlôt, Kovats, Reacher et al., 2017). To ascertain whether flooding caused the increased anxiety, studies have questioned respondents in reference to health impacts before and after flooding (Azuma et al., 2014; Chae et al., 2005), or surveyed specifically on anxiety during rain events (Lamond et al., 2015; Tunstall et al., 2010). The latter have found that over half of respondents reported anxiety when it rains, even years later.

For some individuals, the trauma and anxiety experienced from flooding translates into Post-Traumatic Stress Disorder (PTSD) symptoms (Azuma et al., 2014; Bei et al., 2013; Bokszczanin, 2007; Fernandez et al., 2015; Heo et al., 2008; Norris et al., 2005; Paranjothy et al., 2011; Maltais, Lachance, Fortin, Lalonde, Robichaud, Fortin, & Simard 2000; Mason et al., 2010; Tunstall et al., 2006; Waite et al., 2017). Studies that specifically compared the rates of PTSD symptoms in flood survivors to that of the general population still found elevated rates of PTSD among the flood survivors (Collins et al., 2013; Paranjothy et al., 2011; Tunstall et al., 2006). Rates of PTSD however vary between different samples. In a study of over 33,000 individuals in China who experienced flooding, Liu et al. (2006) found that 8.6% of people had symptoms of PTSD, while a study of 58 individuals who experienced flooding found that 22% had symptoms (Heo et al., 2008).

Many studies have documented depression symptoms in individuals who have experienced flooding (Collins et al., 2013; Dixon et al., 2015; Fernandez et al., 2015; Ginexi & Weihs, 2000; Lamond et al., 2015; Mason et al., 2010; Tunstall et al., 2006; Waite et al., 2017)<sup>3</sup>. Many of these symptoms occurred during the flood and months after (Azuma et al., 2014). Studies that specifically compared the incidence of depression symptoms between individuals who experienced flooding and those who did not also found higher incidence of depression symptoms among those who experienced flooding (Collins et al., 2013; Paranjothy et al., 2011; Tunstall et al., 2006), as did studies that compared people's self-reported health before and after floods (Chae et al., 2005).

Few studies looked at medical records for depression symptoms, relying instead on self-reporting. An exception is the longitudinal study by Ginexi et al. (2000), which found that individuals who

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<sup>3</sup> However, more research may be needed as some studies have found no link (Bei et al., 2013).

had a depression diagnosis before a flooding event were more likely to be diagnosed with depression after the flooding event.

## 2.2. Attributes Affecting Vulnerability to Flooding

This thesis recognizes that there are many different definitions for the term 'vulnerability' – this thesis uses the conceptual framework outlined by Füssel (2007), developed for researching impacts of climate change. This framework recognizes there are four attributes required for an understanding of vulnerability – the system (e.g. social or geographic), the attributes of concern (e.g. human health, culture, or biodiversity), the hazard itself (e.g. flooding), and a temporal reference (the “point in time or time period of interest” (p.6)). Vulnerability is thus the susceptibility of “a system's attribute(s) of concern to a hazard (in temporal reference)” (p.6)).

Based on this framework, these various attributes can all impact the vulnerability of individuals to physical and mental health impacts attributed to flooding (Alderman et al., 2012; Du et al., 2010). Based on geographic systems (e.g. floodplains, or the prevalence of grey infrastructure), flooding may be more likely to occur and may be more severe in certain geographic areas. Hazards such as the flood exposure and level of water in the home may exacerbate health impacts (Azuma et al., 2014; Bei et al., 2013; Lowe et al., 2013). These attributes are explored in more detail below. In general in Canada, “vulnerability is enhanced by social inequity...these populations include First Nations, young children, the elderly and others with compromised immune function or other social and environmental disadvantages” (Burton et al., 2015, p.9).

### **Flooding Exposure**

In general, the literature has found that the incidence of health impacts can increase significantly if individuals have greater flood exposure (Azuma et al., 2014; Bei et al., 2013; Fernandez et al.,

2015; Paranjothy et al., 2011). The term 'flood exposure' has varying definitions. Flood exposure can mean water height and repair time (Dixon et al., 2015), "serious home damage, adverse event experiences" (Collins et al., 2013) or simply living in an affected area (Fernandez et al., 2015).

### **Stress Experienced**

The perceived stress that an individual experiences can increase vulnerability to certain mental health impacts. Leaving home can be very stressful, and in many cases increases the risk of psychological distress (Lamond et al., 2015; Maltais et al., 2011; Mason et al., 2010; Murray et al., 2011; Paranjothy et al., 2011; Tunstall et al., 2006), although not all studies found a significant linkage (Dixon et al., 2015; Hutton, 2004).

While the whole experience of flooding can be stressful, studies have found specific aspects that may significantly increase stress levels, both during and in the aftermath of a flood. In their study of 158 people affected by floods in Australia, Dixon et al. (2016) found that in the short-term, having a frightening experience, worrying about others, and feeling helpless were the top stressors during a flood. In the aftermath, Dixon et al. (2016) found that experiencing difficulties with insurance providers, the clean-up process, and rebuilding were the top three stressors respectively. Bei et al. (2013) found that experiencing a disruption to daily routine was linked to higher symptoms of PTSD.

### **Access to Social Support and Connection**

Access to social support mechanisms (Murray, Caldin, Amlôt, Stanke, Lock, Rowlatt, & Williams, 2011; Norris et al., 2005) and increased connection with flood survivors (Gordon et al., 2011) reduces the likelihood that individuals will develop negative health impacts. A lack of social support is a risk factor for reduced physical and mental health (Bei et al., 2013).

## **Gender**

There is uncertainty surrounding how a person's gender influences their vulnerability. In their systematic review of the mental health impacts of flooding, Fernandez et al. (2015) found "contradictory evidence regarding the effect of gender...while some papers [(Bokszczanin, 2007; Paranjothy et al., 2011; Tunstall et al., 2006)] found poorer mental health in females following floods, others found no relationship [(Aderman et al., 2013; Bei et al., 2013; Malthais et al., 2000)]" (p.9). In Hutton's 2004 study of individuals affected by the Red River flooding in Manitoba, he found that men and women had similar levels of stress and coping difficulties.

The studies that have found differences suggest that women may be at a higher risk of mental impacts compared to men. Women have been at greater risk of exhibiting mental symptoms (Lowe et al., 2013; Mason et al., 2010; Paranjothy et al., 2010), have reported worse overall health in the aftermath of a flood (Alderman et al., 2013), and have been twice as likely to purchase new drugs for mental health conditions following a flood (Motreff, Pirard, Gorla, Labrador, Gourier-Frery, Nicolau, et al. 2013).

## **Age**

In general, children (Ahern et al., 2005; Lowe et al., 2013; Wade et al., 2004) and the elderly (Alderman et al., 2012; Collins et al., 2013; Lowe et al., 2013) may be more vulnerable to health impacts associated with flooding. This may be due to a range of factors such as compromised health systems (Burton et al., 2016) or reliance on others to move them to safety. Wade et al. (2004) found children less than 12 were more susceptible to gastrointestinal illnesses, while Prado, Strina, Barreto, Marlúcia, Oliveira-Assis, Pas & Cairncross (2003) found that children less than 2-45 months of age were more susceptible to diarrhea if their house was susceptible to flooding. The elderly may also rely on medical services that can become disrupted during flooding, increasing the risk of developing or worsening existing health issues (Alderman et al.,

2012; Lowe et al., 2013). Some studies have found that while the elderly may experience physical health impacts, they experienced better health than younger generations – perhaps because they received assistance earlier or they had advanced coping mechanisms (Hutton, 2004).

During floods, men under age 29 may be at greater risk of dying, and in the aftermath, men over 65 may be at greater risk of physical health impacts compared to mental impacts (Lowe et al., 2013), although the literature is inconclusive.

### **Existing Health Conditions**

Those with existing mental health conditions may experience those worsening symptoms as a result of flooding (Bich et al., 2011; Ginexi et al., 2000; Hetherington, McDonald, Wu & Tough, 2017; Heo et al., 2008). Paranjothy et al. (2011) and Alderman, Turner & Tong (2013) found that having an existing medical condition (not specified) increased the risk of reported psychological distress, anxiety, depression and PTSD following a flood. There is not enough evidence of how existing medical conditions have influenced post-flood health, as most studies do not survey for pre-existing medical conditions.

### **Socio-Economic Status**

Lower socio-economic status (often measured by income level) increases the vulnerability to health impacts from flooding (Burton et al., 2016; 2015; Collins et al., 2013; Lamond et al., 2015). Individuals may live in areas that have a greater risk of flooding to begin with, such as floodplains (Alderman et al., 2015) and may have reduced resources to deal with the immediate and long-term impacts of flooding (Lowe et al., 2013). They also may have pre-existing mental health issues before flooding occurs that could worsen afterwards (Fernandez et al., 2015).

Some studies have attempted to clarify this link, identifying a significant relationship between perceived (Paranjothy et al., 2011) and real (Hutton, 2004) negative impact on finances and heightened psychological distress.

Related to socio-economic status is home ownership. The literature on renting compared to owning a home is inconclusive - two studies found more negative health impacts among renters (Alderman et al., 2013; Tunstall et al., 2006) but many studies have not specifically examined this relationship.

### 2.3 Financial Costs

There is limited refereed literature available on the financial costs associated with the health impacts of flooding. The studies that do examine financial costs document an increase in visits to health services (Bennet, 1970; Hander & Smith, 1983; Knowlton et al., 2011; Tunstall et al., 2006) and a rise in medication purchases (Hoppe et al., 2012; Huang, Tan, Zhou, Yang, Benjamin, Wen, Li et al., 2008; Motreff et al., 2013; Sahni et al., 2016; Turner, Alderman, Huang & Tong, 2013). Three other studies documented a disruption in medication use (Alderman et al., 2012; Bich et al., 2011; Lowe et al., 2013), which can translate into increased costs if the individual has to pay for these themselves.

Costs may also include lost salary because individuals need to take time off work to deal with health impacts (Malthais et al., 2000). Malthais et al. (2000) found that 12% of individuals whose homes were flooded took time off work or were absent due to sickness, but there was no calculation of what that cost was to the individual. If the time off work was unpaid this would be much costlier compared to paid sick leave.

If individuals exhibit health impacts from flooding and then work, their productivity may suffer - an effect called 'presenteeism' (working while sick). In their 2004 study on health, absence, short-term disability and presenteeism evidence for 10 common health conditions among American workers, Goetzel, Long, Ozminkowski, Hawkins, Wang, & Lynch, found that presenteeism was responsible for 18% to 60% of all health costs. The same study found that conservative estimates of presenteeism from "Depression/sadness/mental illness" cost \$140.57 USD per employee per year (2004 dollars). This suggests that even where employees may not purchase medication or claim days off work due to sickness, there is still a cost to employers.

### **Increased Visits to Health Services**

There have been few studies in the last 20 years that examined the financial costs associated with health service visits resulting specifically from flooding. Two exceptions are Tunstall et al. (2006) and Knowlton et al. (2011). Tunstall et al. (2006) found that a "minority of flood victims (23%) consulted a doctor in reference to these illnesses, injuries and psychological effects which they attributed to the flood event and 20% received treatment from the doctor" (p. 368). Knowlton et al. (2011) documented two premature deaths, 43 hospitalizations, 263 emergency visits and 3,076 outpatient visits due to the Red River flooding in North Dakota in 2009, at a combined total of \$4.6 million (2008 USD) in health costs and a normalized cost of \$145,495 (2008 USD) per 1,000 people. However, due to data limitations, Knowlton et al. (2011) did not include chronic health issues, nor did the study include lost productivity time for individuals having to visit these health services. Nabangchang, Allaire, Leangcharoen, Jarungrattanapong, & Whittington (2015) included patient visits to doctors in their analysis of flooding costs to households, but the number of doctor visits is not shared in their article.

The first study to document hospitalizations due to flooding is Bennet (1970). This study found that hospital admissions and referrals for those who experienced flooding in Bristol, England,

almost doubled compared to the year before among the same group of people. Handmer and Smith (1983) also found that “hospital admissions were closely related to the degree of flood risk” (p.221) - flood risk depended on the level of water in the home and whether the home was on a floodplain. In Handmer and Smith’s study, while admissions doubled for males who experienced flooding, admissions decreased for women who experienced flooding (the authors did not speculate on the cause).

### **Medication Use**

Some studies have documented a rise in medications following flooding, whether by tracking sales of medication (Motreff et al., 2013; Sahni et al., 2016) or self-reporting (Hoppe et al., 2012; Huang, Tan, Zhou, Yang, Benjamin, Wen, Li et al., 2008; Turner, Alderman, Huang & Tong, 2013).

While two studies found an increase in medication, the types of medication differed. Following the 2013 Alberta floods, Sahni et al. (2016) found that for women in High River, anti-anxiety medication and sleeping aids increased by 164% and 232% respectively in the six weeks after the floods, but there was no increase for men. There was no increase in anti-depressants for either men or women. On the contrary, Motreff et al. (2013) found an increase in three main types of drugs that included those used for anxiety, sleeping difficulties, PTSD and depression for both men and women who experienced flooding. In that study, the increase in new medication was also twice as high for women compared to men.

### **Disrupted Medications**

The literature has documented that flooding may disrupt medication use, which can worsen existing health issues and thus increase the health cost in the immediate and long-term (Alderman et al., 2012; Bich et al., 2011; Lowe et al., 2013). This may be because flood survivors may lose their medication in an evacuation, or infrastructure may be flooded, which impedes them from

reaching necessary health services. However, this literature review did not find studies that only examined flooding and that calculated the cost of these disruptions.

## 2.4 Discussion of Literature Review Findings

While the health impacts from flooding globally are well documented, there are many gaps in the literature, outlined below.

### **Lack of Consensus on Long-term Terminology**

There is a lack of consensus on the definition surrounding long-term health impacts (Du et al., 2010), which increases the difficulty for researchers to investigate these long-term impacts. Without a clear consensus, researchers may find studies that profess to share long-term results when those results only document health impacts several months after a flooding event, omitting potential impacts occurring multiple years later. Du et al. (2016) defined long-term as the reconstruction phase, although reconstruction can last for months to years. Lowe et al. (2013) defined long-term as over three months, while Zhong, Yang, Toloo, Wang, Tong, Sun et al. (2018) defined long-term as over 6 month in their systematic review of long-term studies. Few studies (Lamond et al., 2006; Tunstall et al., 2006) defined it as multiple years. This lack of consensus on terminology increases difficulty for researchers when comparing health impacts that occur over similar time periods. This lack of consensus makes it appear that there is more research done on health impacts occurring years after an event than there actually is.

### **Lack of Long-term Studies**

Not only is there a lack of consensus on terminology, but there is also a lack of research on health impacts defined as long-term (Ahern et al., 2005; Alderman et al. 2012; Fernandez et al., 2015; Milojevic, 2011; Murray et al., 2011). Only a few studies specifically focus on health impacts that occurred years after a flooding event (Dixon et al., 2016; Lamond et al., 2013; Milojevic et al., 2011; Tunstall et. al., 2006). The majority of research on the health impacts of flooding employed one-time surveys or surveys that questioned respondents in reference to health impacts when

the flooding occurred. Some studies have done surveys at different time intervals, such as the study by Azuma et al. (2014) that surveyed individuals within a week, after a month and after six months of flooding. However even this study did not do follow-ups longer than six months.

This lack of long-term research is particularly true for mental health impacts (Ahern et al., 2005; Alderman et al., 2012; Fernandez et al., 2015). In their systematic literature review, Fernandez et al. (2015) noted, “there is a lack of studies that report on results from monitoring on the ongoing mental health of the population affected by the flood. Most of the studies were conducted during the first year, with no medium to long-term follow up” (p.12).

This lack of long-term research is a challenge because many health impacts persist longer than six months, and some, particularly mental impacts such as anxiety or PTSD, may only manifest themselves after multiple months (Fernandez et al., 2015). With an uncertain understanding of these long-term impacts, it may be difficult to understand what resources are needed to address mental challenges resulting of flooding.

### **Research Design Gaps**

Fernandez et al. (2015) noted that the majority of studies included in their systematic review relied on quantitative methods. The 10 studies that used only qualitative methods had limitations too, not always describing the sampling procedures and the role of the researcher. This is despite the fact that using both quantitative and qualitative in a mixed methods approach “enriches the conclusions, gaining a depth of understanding to the problem” (p.13). An exception of a study that did use mixed methods is Tunstall et al. (2006) - the researcher included focus groups, interviews and a survey for individuals who had their homes flooded.

Another issue is that the majority of studies used self-reporting compared to official medical records. This may be because answers to self-reported questionnaires are easier to obtain compared

to medical records. However, medical records will provide factual documentation of health impacts while individuals may over or under-report certain symptoms. Those studies that did look at medical records (Motreff et al., 2013; Sahni et al., 2016) did not include qualitative interviews to augment the research.

Finally, many studies lacked a control group, making it difficult to determine whether health impacts were a direct result of the flood (Fernandez et al., 2015; Lowe et al., 2013; Mason et al., 2010). Those that did include a comparison did not always include similar controls – for instance, Collins et al. (2013) investigated the health impacts of Hispanics in Texas who experienced flooding, but the control was the general US population.

### **Recall Bias**

Many of these studies took place months or years after a flooding event, and it is possible that participants could suffer from recall bias (Ahern et al., 2010; Schmitt et al., 2016; Verger, Rotily, Hunault, Brenot et al., 2003). Some studies surveyed participants in reference to the time during or immediately after the flood (Azuma et al., 2014), while others surveyed participants in reference to health impacts between the flood event and the present (Alderman et al., 2013; Waite et al., 2017). Dixon et al. (2015) did both as their study interviewed people 18-20 months after they experienced severe floods, and then followed up with them again three and a half years later. In the first phase of the study, the researchers surveyed participants in reference to health impacts during and immediately after the flood, and in the second phase, they surveyed respondents in reference to health impacts experienced up to the present. In their study of individuals in France who experienced flooding, Verger et al. (2003) note that “The subjects’ reports of their disaster-related experiences are by nature subjective and were collected retrospectively, five years after the event in this study: they may not be entirely reliable” (p.440).

While studies that occurred years after the flooding event have cited literature that suggests individuals have a strong ability to recall information after a disaster (Lamond et al., 2015; Tunstall et al., 2006), the recall bias is still an important consideration when assessing these studies. Individuals may remember major health impacts that occurred at the time, but may not remember seemingly small symptoms that may contribute to major health impacts in the long-term. Individuals may also “exaggerate the severity of their losses if they believe this might help them to obtain further assistance.” (Schmitt et al., 2016, p.10). In summary, with self-reported health impacts, it is important to remember these may be under-reported for small symptoms, and over-reported if participants have a financial incentive to do so.

### **Limited Research on Financial Costs Associated with Health Impacts from Flooding**

Overall, while the literature has documented numerous health impacts associated with flooding, both physical and mental, there is limited information on the financial costs associated with those health impacts.

In a scoping review of 20 articles on that evaluated the financial impact of weather-related disasters, Schmitt et al. (2016) found that studies have focused significantly on heat risk, and they “ignore the health costs associated with other weather-related extreme events, such as droughts, floods and hurricanes” (p.2).

This lack of research on financial costs is a key research gap, because a more complete understanding of the costs associated with these health impacts can support directing resources more efficiently and identifying priority areas of concern.

### **Geographic Limitations**

Although flooding greatly affects developing countries, the research is “dominated by studies of slow-onset floods in high-income countries that may have little relevance to flash floods and floods in low-income settings” (Ahern et al, 2005, p.43). Schmitt et al. (2016) found that in their analysis of studies that evaluated the financial impact of disasters, “no study has covered Central and Latin America, the Middle East nor Africa” (p.8). Zhong et al. (2018) found that in their systematic review of long-term health impacts from flooding, “the experiences of other middle and low-income countries frequently affected by flooding, such as Vietnam, Bangladesh, Nepal and Indonesia, were not investigated” (p.170). This geographic focus is a research gap, as “variations in population, density, resources, and building codes between developed and developing countries will alter the health impact” (Du et al, 2010, p. 270).

## **Summary**

While there are documented mental and physical health impacts from different types of flooding around the world, there are still many research gaps. Few studies have a valid control, include long-term health impacts, or examine financial costs. Additional research is needed that assesses these impacts and their financial costs so the society can adequately prepare for the flooding yet to come.

## 3.0 Methods

This section summarizes the research methods for this thesis. The research used a mixed methods approach, which “enriches the conclusions, gaining a depth of understanding to the problem” (Fernandez et al., 2016, p.13). All 100 respondents from flooded and non-flooded households were interviewed on quantitative questions relating to specific health impacts and financial costs, and respondents provided additional qualitative information about their experience. This approach was best suited to answer the research questions below (Cresswell, 2014): the quantitative questions allowed the author to capture numerical data that could be analyzed statistically, while the qualitative questions provided additional context and rationale for respondents’ answers. The research questions included:

1. What are the short-term and long-term mental and physical health impacts associated with residential basement flooding?
2. What are the attributes affecting vulnerability to identified health impacts?
3. What are the mental and physical health financial costs associated with residential basement flooding?

The research method was door-to-door interviews, and the questions were tested and refined to integrate any feedback in a test-pilot before conducting the rest of the interviews (see Section 3.2).

The steps completed for this thesis are below.

- conducted literature review (see Section 2),
- designed interview structure and questions based on the literature,
- identified research site,
- conducted test-pilot,

- integrated feedback from pilot participants to refine interview questions,
- conducted door-to-door interviews,
- transcribed interview results and notes into Excel,
- analyzed results, and
- wrote thesis.

These steps are explored in further depth below.

### 3.1 Interview Design

#### **Interview Questions**

There were two versions of interview questions – one for respondents in flooded households, and one for respondents in non-flooded households (the control) (See Section 3.2 “In the Field”). See appendix A for questions posed to respondents in flooded households, and Appendix B for questions posed to respondents in the control. These questions were all based on findings in the literature review (see Section 2.0). The authors also collected demographic information (e.g. number of people per household, their sex and age range and household income level) to correspond with Statistics Canada data.

During each interview, respondents from flooded households were interviewed in reference to health impacts (sleeping difficulties, new breathing difficulties, stomach cramps, skin irritations, worsening of existing health issues, and worrying and stress) that occurred over two time periods: within the first 30 days (1 month) of experiencing flooding, and anytime after those first 30 days. Non-flooded households were interviewed in reference to health impacts that occurred between August 2014 and Spring/Summer 2017, when the interview was conducted<sup>4</sup>.

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<sup>4</sup> Three years was chosen because this was the same time period for households that shared long-term health impacts following the August 2014 flood. Since surveys were done in April to August 2017, this was approximately three years since the August 2014 flood.

To answer the second research question on attributes that affect vulnerability to health impacts in the first month of experiencing a basement flood, the author included questions in reference to factors identified in the literature (e.g. flood exposure, difficulty contacting an insurance provider, and the lack of social support) that can influence vulnerability - see Appendix C. The author hypothesized that these could contribute to the severity of the health impacts experienced.

To answer the third research question on associated mental and physical health financial costs, the author included questions in reference to days off work, health service visits (e.g. visits to family doctors, walk-in clinics, a therapist or counsellor, and a hospital), medication use, and property and casualty insurance coverage<sup>5</sup>.

To maximize response rates, the author ensured the interview could be done in 10 minutes. As well, there was a prize draw for a \$100 gift card as an incentive.

All questions received Ethics clearance by the University of Waterloo Office of Research Ethics.

### **Interview Method: Door-to-Door Interviews**

Door-to-door interviews were chosen as the research method for several reasons:

- **Improved Accuracy for Screening Participants:** Originally, a screening question was whether a household had ever experienced flooding in the last several years. However, during the interview pilot, the author found that there was a varying understanding of the term 'flooding' among households. For instance, one participant said they had never experienced flooding, but that they had experienced some leaks in the basement. Upon further questioning, the author identified that the leaks were severe enough to be considered 'flooding' for the purposes of this research. If the interview had only been

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<sup>5</sup> Along with a financial cost, limited or lack of property and casualty insurance could be an attribute correlating with higher worry and stress.

online or mailed-in, these subtleties would have been lost, and there was a risk that participants who had actually experienced flooding would answer the interview for the control group instead.

- **Increased Comprehension:** the author explained questions and terminology in person, increasing the likelihood the participant would understand the questions. In an online or mailed-in interview, descriptions can be provided, but these may not be enough for a participant to fully understand the questions.
- **Ease of administration:** compared to an online or telephone survey, a door-to-door interview was also easier to administer, for the main reason that email addresses and telephone numbers for households affected by flooding are difficult to obtain, while it is relatively straightforward to identify flood-impacted neighbourhoods from media articles.
- **Increased number of completed interviews:** since the author interviewed participants herself, there was no chance participants would miss a question by accident. Unlike online or mail-in surveys, participants of in-person interviews cannot skim through questions quickly nor answer randomly. Explaining questions in person instead of online also increases the likelihood of completed interviews.

## **Study Site**

The City of Burlington was chosen due to following reasons:

- Burlington experienced severe flooding when two months' worth of rain (196 mm) fell in eight hours on August 4<sup>th</sup>, 2014, when over 3,500 homes were flooded (Halton Conservation, 2015),
- Three years was sufficient time for some long-term mental health impacts to manifest themselves (Sahni, Scott, Beliveau, Varughese, Dover & Talbot 2016), and

- Three years was within a timeframe where respondents would be able to remember many immediate impacts (Tunstall, Tapsell, Green, Green, Floyd, & George, 2006).

The author identified flood-impacted neighbourhoods from media articles, input from the city of Burlington, and from local residents who identified locations that experienced flooding. Because the flooding was so widespread, many respondents were eager to voluntarily share the names of additional neighbourhoods that had experienced flooding.

## 3.2 In the Field

### Test-pilot

The author test-piloted the interview questions in March 2017. The purpose was to test the interview questions and determine whether any adjustments needed to be made. Seven households – two that had experienced basement flooding, and five that had not – were interviewed.

While respondents generally understood the questions well, the term “flooding” and the term “debilitating worrying and stress” caused confusion. As a result, the author made several changes to the interview questions, summarized below:

- **Changed “Flooding” to “Water in the Home” when explaining the interview to residents before conducting the interview** : Instead of interviewing households about whether they had experienced flooding in their home, the author interviewed respondents in reference to whether they had ever experienced *water* in their home – this allowed the author to determine whether the amount of water someone experienced in their home warranted the definition of a flood (e.g. water from a leaky pipe in a bathroom that was quickly contained was not considered “flooding”)
- **For the control, removed the question:** “*Within the first month of experiencing water in your basement, did you or any members of your household experience stomach*”

*cramps?*". For respondents who had not experienced flooding, the question made them uncomfortable. If a respondent had experienced flooding, they generally understood that stomach cramps could be an associated physical health impact.

- **Changed “Debilitating Worrying and Stress” to “Worrying and Stress beyond the Normal and Everyday”**: This reduced confusion around the word ‘debilitating’ and also emphasized that the author was interested in the respondents’ perspective of what their normal and everyday was.
- **Added the question “how long have you lived in this house?”**. Respondents suggested that people could move into homes that had been previously flooded, and be unaware of any mould resulting from the flood. This would create a subset of respondents who could be experiencing breathing difficulties but not know why.

Testing the interview questions in advance of the finalized interview was highly beneficial to maximize comprehension.

### **Door-to-Door Interviews**

Between March and August 2017, the author went to 511 houses in flood-impacted neighbourhoods and approached 233 people in those houses to take the interview (278 were not at home). Of those people, 43% agreed to do the interview (n=100). A total of 58% were from flooded households (n=58) and 42% were from non-flooded households (the control) (n=42). Both flooded households and non-flooded households were in close proximity to one another (i.e., less than one km separation). Participants had the opportunity to read an information letter before signing a consent form. One person per household acted as the respondent<sup>6</sup> on behalf of the entire household (there were 171 members of flooded households,

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<sup>6</sup> Respondents would occasionally demand a nearby household member to corroborate answers (e.g. water height, or length of time to process a property and casualty insurance claim). However, the author emphasized that only one household member was to respond directly to the interview.

and 122 members of non-flooded households). Respondents would occasionally ask a household member to corroborate factual answers (e.g. how high water was, or how long it took to process an insurance claim), but the author emphasized that only one household member was to respond directly to questions to ensure the data collected was consistent across all households. No respondent was under the age of 18 - when those who appeared younger than 18 answered the door, the author inquired whether someone else was home. Interview responses were collected on paper.

The author conducted interviews during weekday evenings (4 pm – 8 pm) and weekends (between 9 am and 7 pm). Weekends between 2 pm and 5 pm were the most effective time to complete interviews (calculated as the number of interviews completed out of a total number of people the author engaged with). During that time, between 64% and 100% of people the author approached agreed to do the interview.

The sample size of 100 households was chosen as there was very limited variance between answers once this sample size was reached.

### 3.3 Analysis

Results were analyzed using the Chi-Square test and Fisher's Test to determine whether there were any statistically significant differences between the responses from flooded and non-flooded households. Chi-Square was used in all cases except where the expected value for a specific frequency was lower than five – in those cases, Fisher's Test was used. A two sample t-test was used to test significance for the question "how worried do you get when it rains, on a scale of 1-5". Statistical significance was considered to occur where  $p < 0.05$  (95% confidence interval).

### 3.4 Limitations

While this research design method was chosen to maximize the number of completed interviews and obtain a wide range of data points, there are limitations that must be stated to form a clear understanding of the thesis.

- While the author expects that many of the health impacts and associated financial costs (see 5.0 Results) are applicable in other communities that have experienced flooding, **additional research is needed to determine the broad-based applicability of this research** beyond the City of Burlington.
- The sample size of 100 households was chosen as beyond this point there was limited variance in the responses. However, a larger sample size may have reduced the possibility of a Type I or Type II error.
- **The interviews relied on self-reporting.** While this yielded a depth of understanding in reference to people's experiences, there are limitations, including the following:
  - There was no medical data to corroborate findings. Additional research that integrates healthcare and/or life and health insurance data could demonstrate whether there were any increases for medication or visits to health services in previously flooded areas.
  - Social desirability (the propensity of respondents to give answers they think are favourable to others, compared to answers that reflect their real thoughts (Bryman & Bell, 2016; Grimm, 2010)) **may have resulted in respondents' under-reporting impacts, particularly for visits to therapists or councilors or medication use.** For many, there is still a stigma surrounding resources for mental health challenges and if respondents were embarrassed, they may have

been disinclined to share this information (Tourangeau & Yan, 2007, Van de Mortal, 2008).

- The interview was an original design, purposefully structured to incorporate a wide range of questions about health impacts, health services and financial costs. As a result, it did not include standardized scales that have been developed to identify mental health outcomes (e.g. Post-Traumatic Stress Disorder). Thus, **mental health impacts may be under-reported**. In addition, because the questions are original, the outcomes cannot be directly compared to outcomes from other studies that have used standardized scales to determine if there are patterns that hold true in other communities. This **limits the generalization of the findings**.
- People from non-flooded households may have been impacted by the flood event simply by being located where flooding occurred. These people may have taken time off work to help friends, family and neighbours. They also may have seen the flooding and been worried it would happen to them. **The control is thus not comparable to residents who have never lived in an area impacted by flooding**.
- The door-to-door research garnered a wide range of qualitative data, but it is possible that some respondents may have been even more responsive in a private setting where they did not need to verbalize information to the author in person (e.g. when conveying information on medication use). As well, door-to-door interviews are by nature social, which can lead to social desirability bias. **This may have led to under-reporting of medication use for mental health impacts and mental health impacts themselves**.

## 4.0 Respondent Details

All respondents were in neighbourhoods that had experienced flooding. The respondents were split between households that had experienced flooding in the last three years (n=58), and households in the same neighbourhood that had not experienced flooding in the last three years (the control) (n=42). The demographics of the households that were flooded, the control group, the City of Burlington, Ontario, and Canada are displayed in Table 3. Data for the City of Burlington, Province of Ontario and Canada originates from the 2016 Census (Statistics Canada, 2017).

Table 3: Demographics of Households Members from Study, City of Burlington, Ontario and Canada

	Flooded Households Interviewed (n=58 households)	Non-Flooded Households Interviewed (n=42 households)	City of Burlington	Province of Ontario	Canada
Average Household Income	\$100,000 or above	\$100,000 or above	\$93,588	\$ 74,287	\$70,336
% Own Their Home	97%	97%	76%	70%	68%
Average Size of Families	3.04	3.17	2.9	2.9	2.9
0 to 5 years	6%	12%	17% for total under 14 years*	16% for total under 14 years*	17% for total under 14 years*
6-14 years	9%	12%	17% for total under 14 years*	16% for total under 14 years*	17% for total under 14 years*
15-24 years	16%	12%	11%	13%	12%
25-64 years	50%	54%	53%	54%	54%
≥65 years	15%	11%	19%	17%	17%
High school diploma or certificate	9%	9%	26%	27%	26%
Apprenticeship or trades certificate or diploma	3%	5%	5%	6%	10%
College, CEGEP or other non-university certificate or diploma	16%	21%	24%	21%	19%
University certificate or diploma below bachelor level	12%	7%	2%	2%	3%
Bachelor's degree	22%	30%	21%	17%	15%
University certificate, diploma or degree above bachelor level	28%	26%	10%	9%	8%

The demographics between the flooded households and the control are similar. The number of females and males in the flooded households compared to the control differed by only 1%.

There were fewer children aged 0 to 5 years (6% compared to 12%) and more seniors (15% compared to 11%) in the flooded households compared to the control group, but these differences were not statistically significant. Both groups had similar household income levels.

There were two main differences between the general population of the thesis and the City of Burlington, the Province of Ontario and Canada:

- 1) The households in this thesis were generally more financially affluent compared to households in the City of Burlington, the province of Ontario, and Canada, as indicated by household income level, home ownership, and education levels (see Table 3 above).
- 2) The City of Burlington has a higher percentage of seniors (23%) compared to the households in this thesis (15% and 11% among the flooded households and non-flooded households respectively). This may be because the author only visited detached and semi-detached homes instead of visiting long-term care facilities.

## 5.0 Results

This section outlines the findings to answer the three research questions:

1. What are the short-term and long-term mental and physical health impacts associated with residential basement flooding?
2. What are the attributes affecting vulnerability to identified health impacts?
3. What are the mental and physical health financial costs associated with residential basement flooding?

### 5.1 Health Impacts

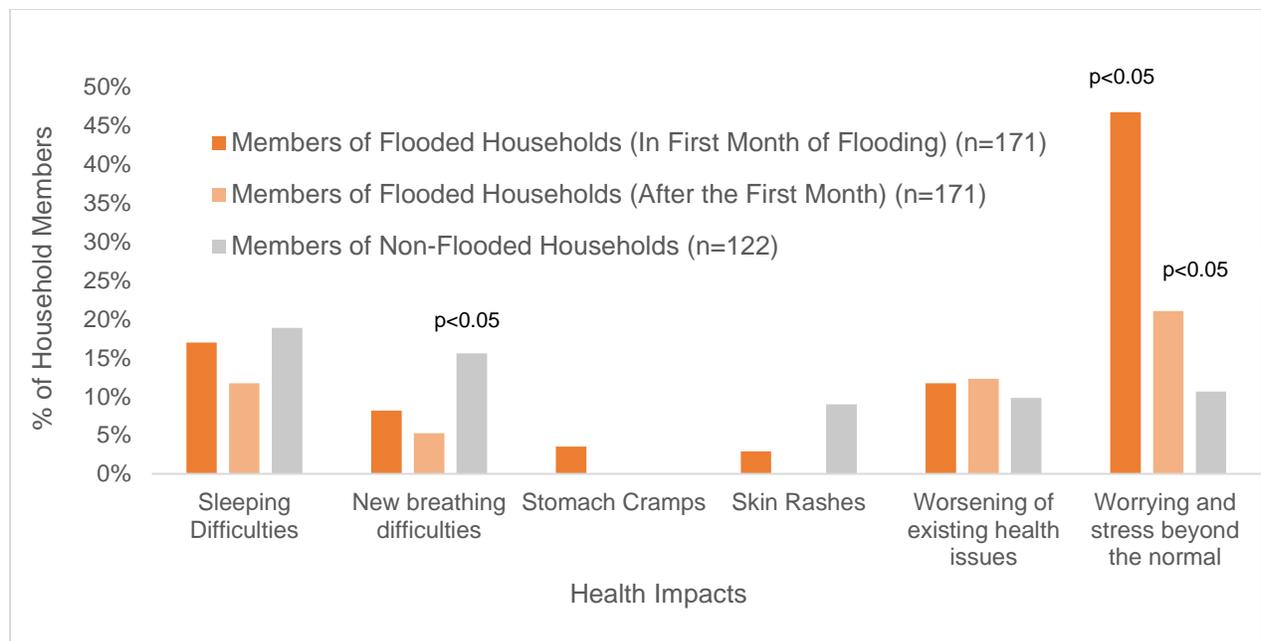
The author interviewed respondents in reference to six health impacts. Four of these were physical impacts (sleeping difficulties, new breathing difficulties, stomach cramps, and skin rashes) while one could be either physical or mental (worsening of health issues) and one was mental (worry and stress beyond the normal and everyday).

**Health Impacts Experienced:** Worry and stress beyond the normal and everyday and breathing difficulties were the only health impacts where there was a statistically significant difference between flooded households and the control (Figure 3). While other health impacts for the first month were higher than anytime after the first month (except for worsening of health issues), these differences were not statistically significant.

- All flooded household members experienced **significantly higher worry and stress in the first month** compared to anytime after ( $X^2(2, n=342) = 25.26, p<0.001$ ). A total of 47% (n=80) of flooded household members experienced worry and stress in the first month of flooding, compared to 21% (n=36) of flooded households that experienced worry and stress after the first month.

- All flooded household members experienced **significantly higher worry and stress after the first month compared to the control** ( $X^2(2, n=293) = 5.53, p<0.01$ ). A total of 21% (n=36) of flooded households experienced worry and stress compared to 11% (n=13) of the control.
- Members of the control experienced **significantly higher breathing difficulties** compared to members of flooded households ( $X^2(2, n=293) = 8.76, p<0.05$ ). A total of 16% (n=19) of members of the control had new breathing difficulties, compared to 5% (n=9) of the flooded household members after the first month of flooding.

Figure 3: Health Impacts for Flooded and Non-Flooded Households



The following quotes from respondents illustrate the ‘typical’ worry and stress felt following the flood event.

- “Oh my god it was stressful” – man aged 25-64
- “Some days I just wanted to run away” – woman aged 25-64
- “It’s something you never want to experience again in your life” – man aged 65 or older

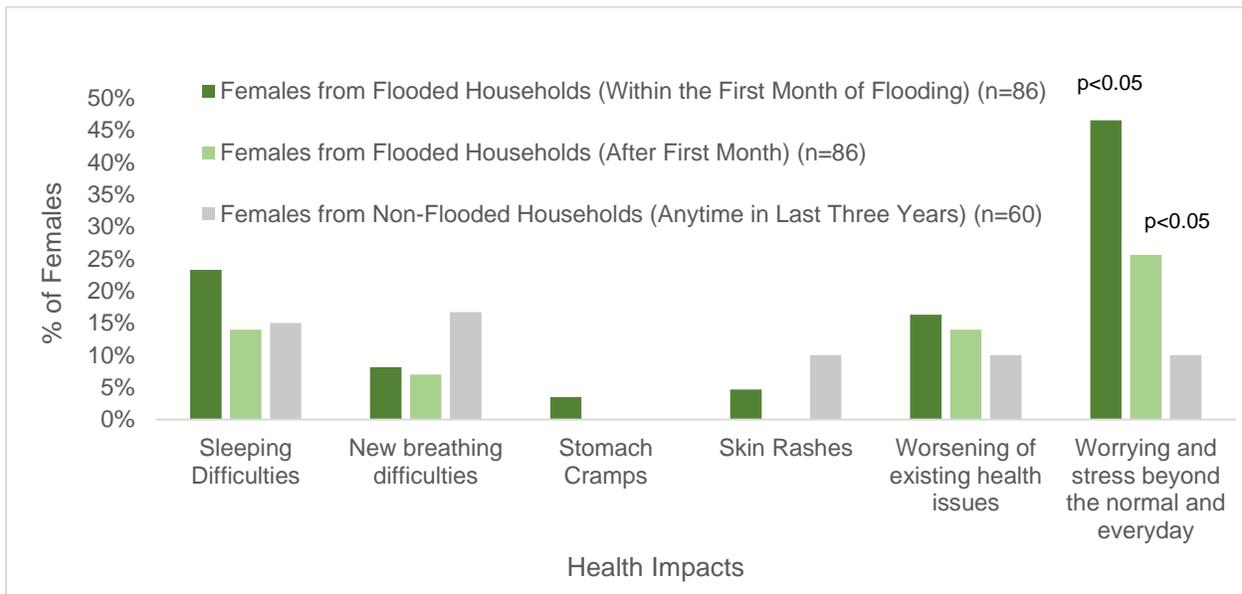
- "It's just an awful, awful experience" – woman aged 25-64

**Females in Flooded Households.** Females in flooded households experienced significant worry and stress (Figure 4):

- Females in flooded households experienced **significantly more worry and stress in the first month compared with anytime after** ( $X^2(2, n=172) = 8.17, p<0.01$ ). A total of 47% (n=40) of females in flooded households experienced worry and stress in the first month of flooding, compared to 26% (n=22) after the first month.
- Females in flooded households experienced **significantly more worrying and stress compared to females in the control**, both in the first month ( $X^2(2, n=146) = 21.83, p<0.001$ ) and anytime after ( $X^2(2, n=146) = 5.53, p<0.025$ ). Only 10% (n=6) of females in the control experienced worry and stress in the last three years.

The rest of the differences were not statistically significant.

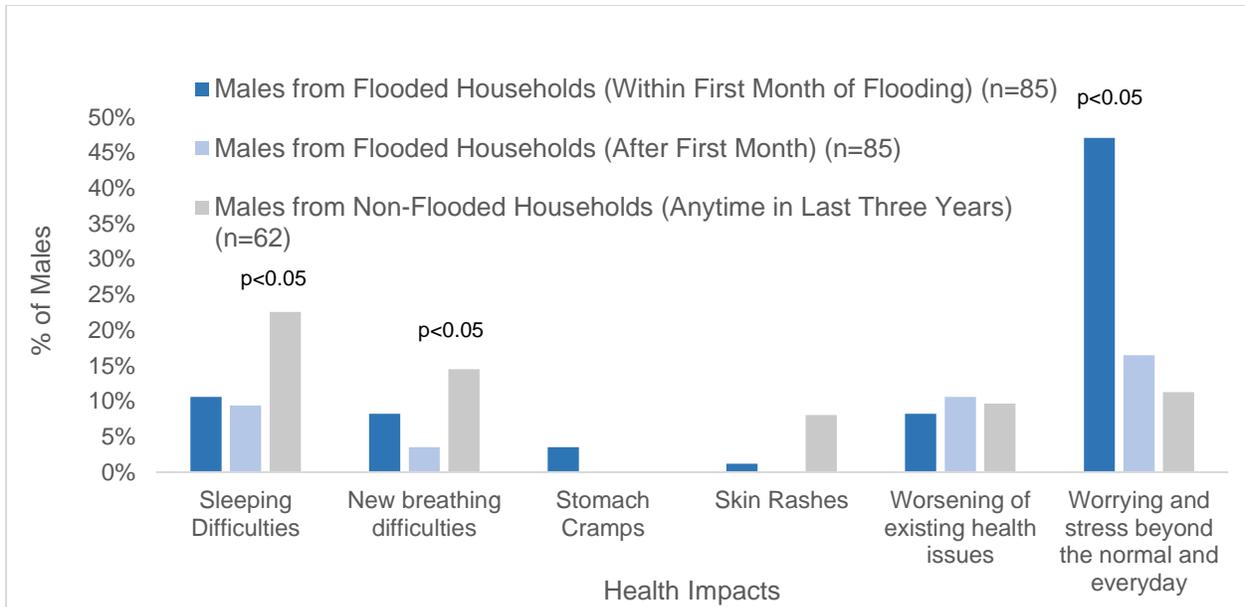
Figure 4: Health Impacts for Females in Flooded and Non-Flooded Households



**Males in Flooded Households.** Males in flooded households experienced significantly more worry and stress than males in the control, while males in the control had significantly higher physical impacts (Figure 5):

- Males in flooded households experienced **significantly more worry and stress in the first month compared to after the first month** ( $X^2(2, n= 170) = 18.35, p<0.001$ ). A total of 47% (n=40) of males experienced worry and stress in the first month of experiencing flooding compared to 16% (n=14) anytime after.
- Males in flooded households experienced **significantly more worrying and stress in the first month compared to the control** ( $X^2(2, n=147) = 21.09, p<0.01$ ). A total of 47% (n=40) of males compared to 11% (n7) of males in the control experienced worry and stress.
- Males in the **control had significantly higher sleeping difficulties** compared to males in flooded households in the first month following flooding ( $X^2(2, n=172) = 3.91, p<0.05$ ) and anytime after the first month of flooding ( $X^2(2, n=172) = 4.89, p<0.05$ ). A total of 23% of males in the control had sleeping difficulties compared to 11% (n=9) of males from flooded households in the first month following flooding and 9% (n=8) of males from flooded households after the first month of flooding.
- The males in the **control also had significantly higher breathing difficulties** compared to males in flooded households after the first month (not during the first month) ( $X^2(2, n=172) = 5.77, p<0.025$ ). A total of 15% of males in the control had breathing difficulties compared to 8% (n=7) of males from flooded households in the first month and 4% (n=3) of males from flooded households after the first month.

*Figure 5: Health Impacts for Males in Flooded and Non-Flooded Households*

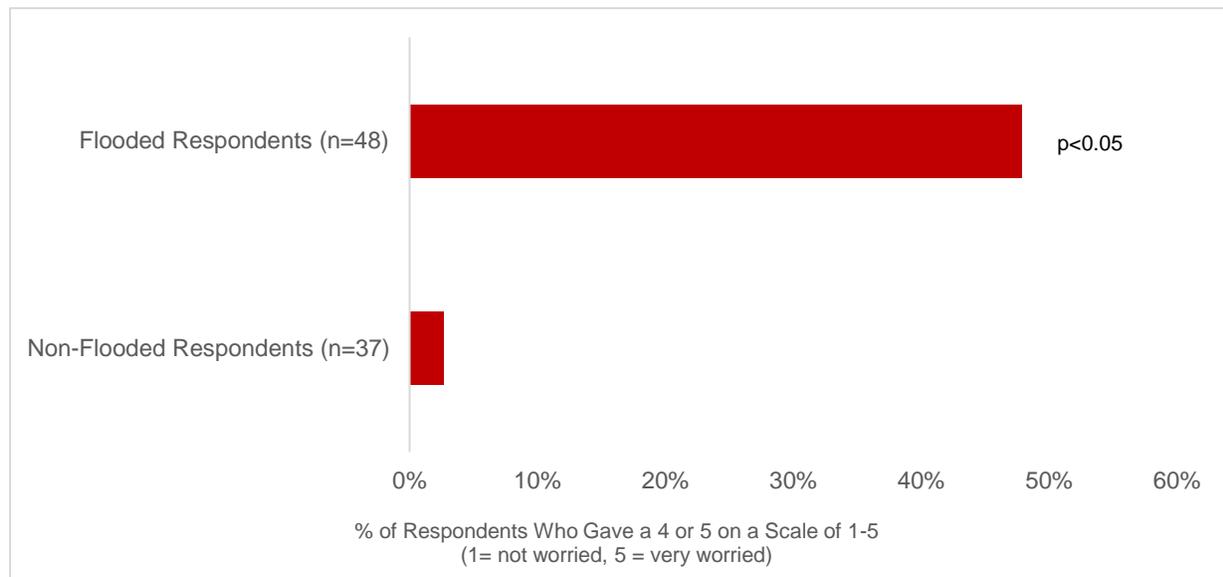


To further analyze the long-term mental health impacts of residential basement flooding, the author interviewed respondents with the following question: “on a scale of 1-5, how worried do you get when it rains? 1 is not worried at all, and 5 is very worried?” Figure 6 below includes answers from respondents who had experienced the August 2014 Flood<sup>7</sup>.

As shown in the Figure 6, respondents from flooded households who experienced the August 2014 flood were significantly more worried when it rains compared to non-flooded households ( $t(83)=4.65$ ,  $p = 6.22E-06$ ). Specifically, 48% of these respondents from flooded households gave a 4 or a 5 compared to only one respondent from a non-flooded household. Only one respondent from the control gave above a 3 – this respondent (aged 25-64) explained he gave a five because “we don’t have normal weather anymore” and “I don’t have the confidence that the city’s infrastructure will handle the deluge”.

<sup>7</sup> As surveys took place between April and July 2017, the respondents would have experienced the August 2014 flood between 2.75 and three years ago. Responses from people who had not experienced the August 2014 flood were removed, as the goal was to capture long-term impacts only.

Figure 6: Responses from Flooded and Non-Flooded Households ~ Three Years After Flooding on How Worried They Are When it Rains



Thus, for many of the respondents, rain was still a source of worry almost three years following a flood. This is reflected in the quotes below from respondents who scored a four or a five:

- “It’s always on my mind” – woman aged 25-64 who dreams of disasters
- “When we have bad weather, you worry” – woman aged 25-64
- “It’s always in the back of your mind” – woman aged 65 or older

Women who responded to this question (n=20) exhibited more worry than men who responded (n=28) ( $t(46) = 2.02, p = 0.02$ ). Specifically, 60% of women from flooded households were still worried when it rains compared to 39% of men. “You have a fear of more rain”, said one woman, “before, I used to like a good thunderstorm, [now] when it rains it makes you more anxious”. For those who answered this question, both females and males who experienced flooding were significantly more worried than females and males in the control. Of those who experienced the August 2014 flood and answered this question:

- 60% of female respondents (n=20) were still worried when it rains, compared to 0% of females in the control (t(34) =4.81, p = 1.5E-05)).
- A total of 39% of male respondents (n=28) were still worried when it rains, compared to 5% of males in the control (t(45) =2.39, p = 0.01).

## 5.2 Attributes Affecting Vulnerability to Health Impacts

To address the second research question on attributes that affect vulnerability to physical and mental health impacts, the author compared results between age groups and between the sexes. As shown in Table 3, there were no significant income differences between the flooded households and the control for analysis.

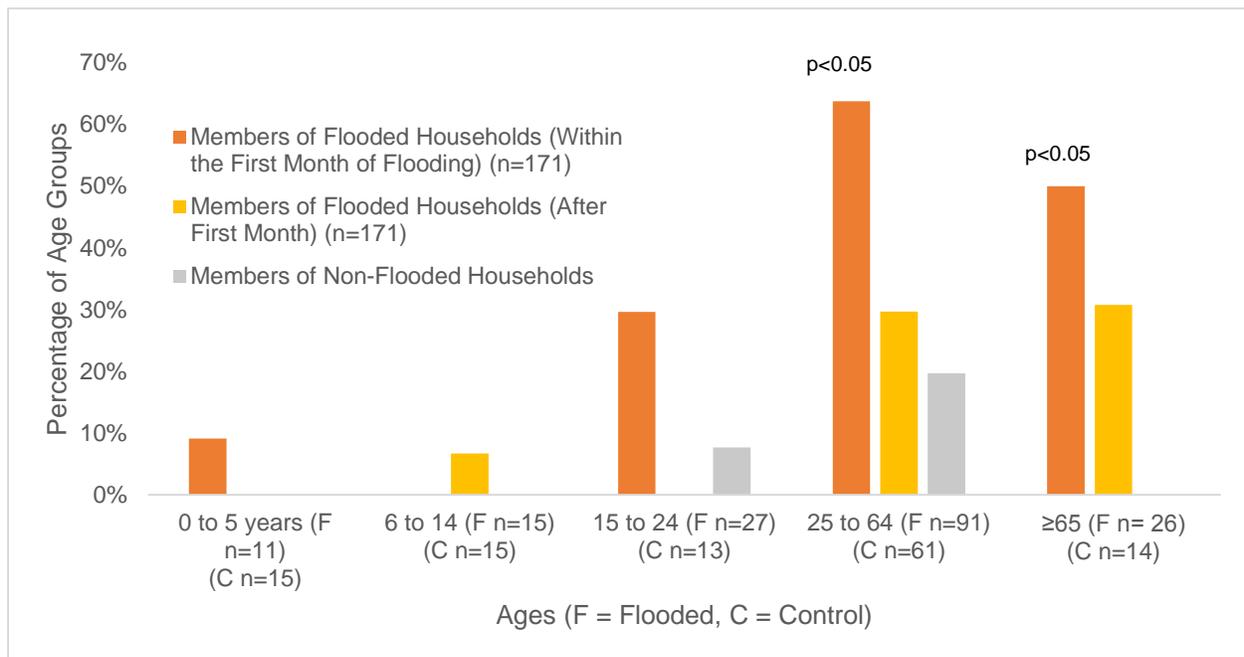
**Health Impacts by Age:** The main difference between age groups was that seniors and adults who were flooded experienced significantly higher worry and stress (Figure 7)<sup>8</sup>. The differences between other age groups were not significant.

- **Seniors (≥65 years) who experienced flooding were significantly more worried compared to seniors in the control**, both in the first month (p = 0.001) and after (p = 0.02). A total of 50% of seniors (n=13) from flooded households experienced worry and stress in the first month, compared to 31% (n=8) anytime after, and compared to zero seniors in the control.
- **Adults (aged 25-64) who experienced flooding in the first month were significantly more worried compared to adults in the control** ( $X^2(2, n=152) = 28.54, p<0.001$ ). A total of 64% (n=58) of adults who experienced flooding were worried in the first month, compared to 30% (n=27) of adults anytime after and 20% (n=12) of adults in the control.

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<sup>8</sup> F = Flooded Household, C = Control Household. The study had 86 females and 85 males in the flooded households. One male did not provide his age, hence why the sum of the figures among flooded households along the x axis is 84.

Figure 7: Worrying and Stress For All Age Groups<sup>9</sup>



In a study by Hutton (2004) examining health impacts of the Red River flooding in Manitoba, he found that seniors had better mental health than younger generations after a flood event. While this thesis conversely showed that many seniors who experience flooding still experience worry and stress compared to the control, several quotes below from male respondents aged 65 or over illustrate a self-sufficiency that echoes Hutton’s study.

- “I’ve been bombed...so flooding, BAH”
- “the reality is you just deal with it”
- I was just “kind of put off by it all”

<sup>9</sup> F = Flooded Household, C = Non-Flooded Households. One male from a flooded household did not provide his age, and three males and one female from non-flooded households did not provide their age, hence the different figures per age group out of all household members in Figure 7.

For all households, adult respondents 18 years and over reported health impacts for children 17 years and younger. Among flooded households, there were 26 youth aged 15 and younger – 11 children aged five years old or younger, and 15 children aged six to 14 years.

Of those household members five years old or younger, only three out of 11 from flooded households had health impacts – these were split between two households. In one family, a parent reported that their two young girls aged 0 to 5 years experienced worse breathing difficulties after the family experienced flooding. In that house, the parent shared how the “air quality is not good” and their basement is “really musty” since the flood. In the other household, the respondent shared how the whole family experienced worrying and stress beyond the normal and every day in the first month of the flood.

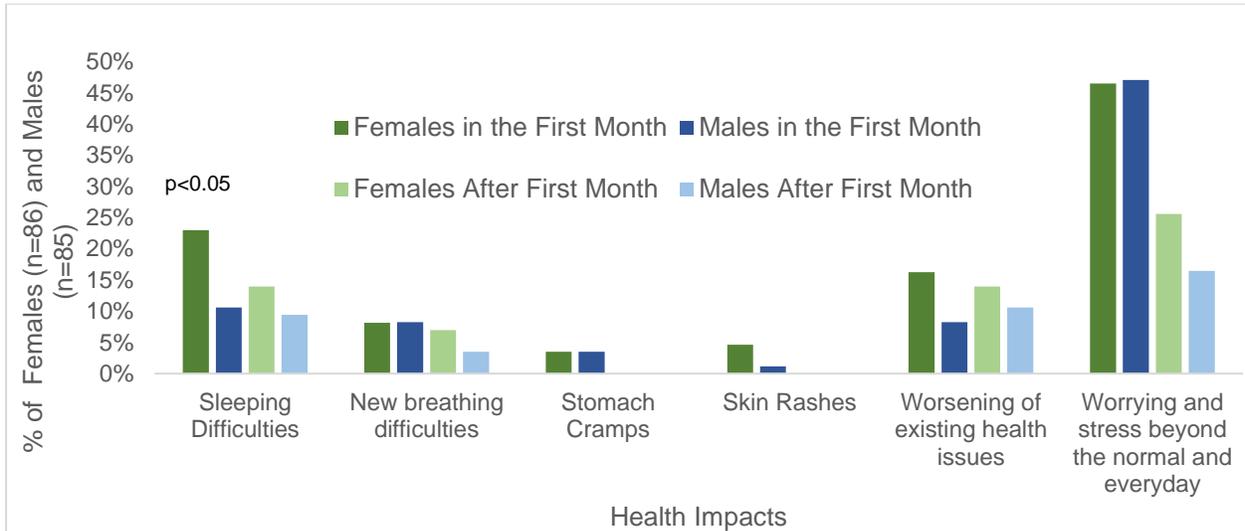
Children aged 6-14 years (n=15) also had few health impacts, with several exceptions. One girl had gone to live with her relatives during the flood event while her parents finished cleaning, and ever since then the child “hates thunderstorms” and becomes anxious when they occur. Another respondent shared how her daughter becomes more worried more often when it rains and climbs into bed with her parents frequently since the flooding event.

**Health Impact Differences between Females and Males:** Among flooded households, the author found that there were similarities between the health impacts that females and males experienced. While females in flooded households experienced a similar or higher incidence of health impacts compared to males in flooded households (Figure 8), these differences were not statistically significant except for the impact below:

- **Female household members experienced significantly greater sleeping difficulties compared to male household members in the first month of flooding** ( $X^2(2, n= 171) = 4.87, p<0.05$ ). A total of 23% (n=20) of females in flooded households compared to

11% (n=9) of males in flooded households experienced sleeping difficulties in the first month ( $X^2(2, n= 171) = 4.87, p<0.05$ ).

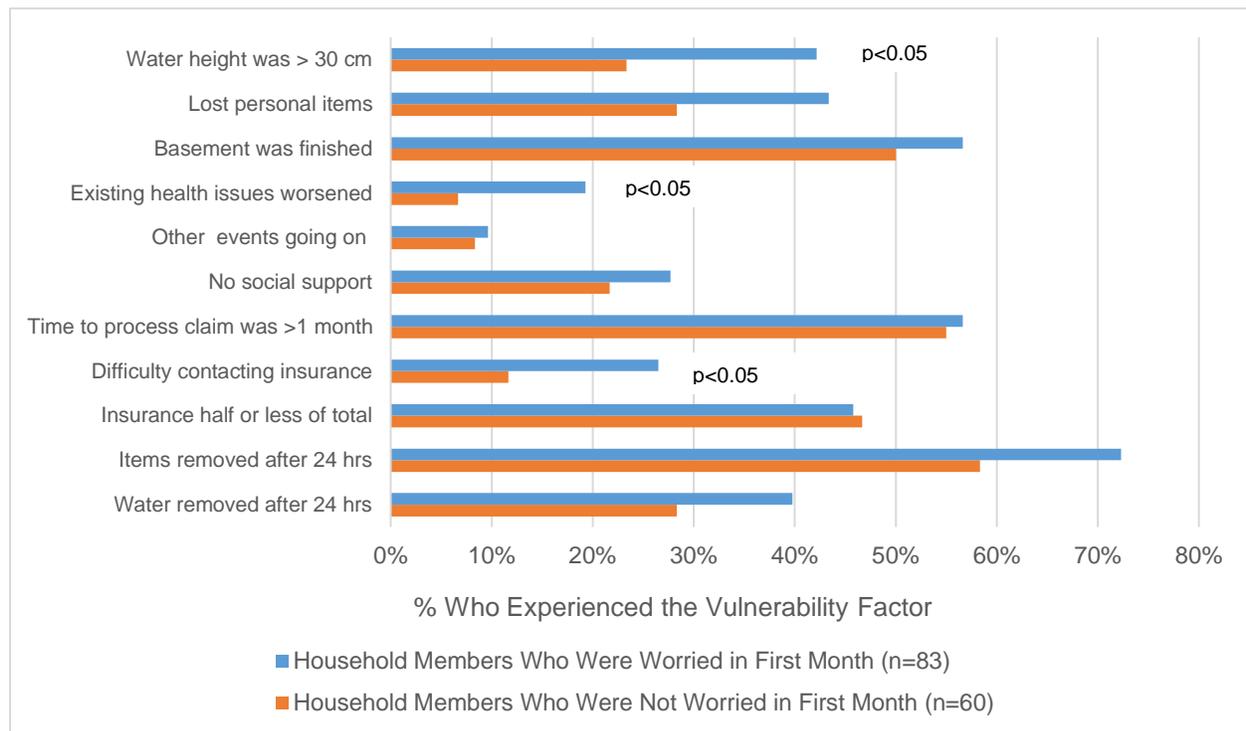
Figure 8: Health Impacts for Females and Males in Flooded Households



To determine attributes that correlated with higher worry and stress in the first month, respondents from flooded households were interviewed on questions on the attributes listed in Table 4 in Appendix C. A comparison of flooded households that exhibited worry and stress within the first month of flooding (n=83) and those that did not (n=60) demonstrated that of the 11 attributes explored, there were three that significantly correlated with worry and stress (Figure 9). These were:

- water height was 30 cm (1 foot) or higher ( $X^2(2, n=143) = 5.49, p<0.025$ ),
- difficulty contacting an insurance provider ( $X^2(2, n=143) = 4.74, p<0.05$ ), and
- existing health issues worsened ( $X^2(2, n=143) = 4.60, p<0.05$ ).

Figure 9: Potential Attributes Correlating with Worry and Stress in the First 30 Days After a Flood in Burlington, ON



Although it did not significantly correlate with higher worry and stress, the loss of personal items anecdotally greatly affected respondents and it was a common shared experience. Families shared how they lost their children’s artwork, their academic papers, their own high school yearbooks, and antiques. As one family stated, “we lost quite a bit of irreplaceable stuff”.

### 5.3 Financial Costs

This thesis examined financial costs associated with residential basement flooding, including visits to health services, medication use, days off work, and property and casualty insurance coverage. This helped the author gain a broad understanding of the costs associated with residential basement flooding.

## Visits to Health Services and Medication Use

For this thesis, the author hypothesized that there would be an increase in visits to health services and medication use among the flooded households. However, there was **no significant difference between the flooded households and the control** and thus no significantly higher financial costs.

While this thesis did not identify significant differences in visits to health services and medication use between flooded households and the control, some households (see below), shared how they visited health services and/or increased medication use due to health impacts they attributed to flooding.

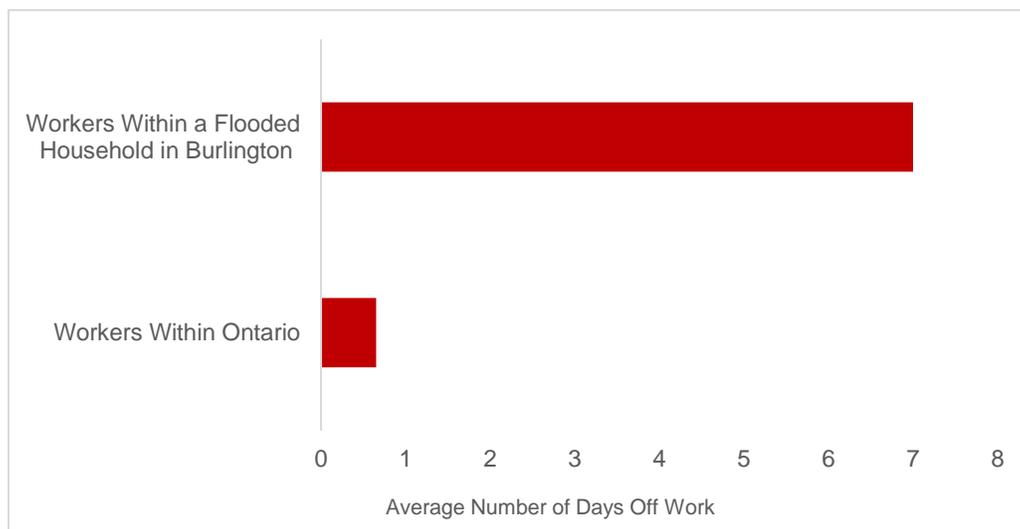
One respondent shared that they had been diagnosed with Post-Traumatic Stress Disorder (PTSD) directly because of the floods. During the interview, they said that the recent floods in Ontario and Quebec had triggered them again and they were currently off work as a result. Their family had suffered financial hardship because of the flood damage, and the respondent had experienced severe stress that manifested itself into stomach cramps and eczema in the first month. The respondent admitted that they do not like to medicate, but that it was often necessary to function. They had been to a therapist, a family doctor, and a hospital because of the PTSD.

One female respondent (aged 25-64) shared how she went to her naturopath for sleeping aids because of the stress from the flooding. Another female respondent (age 25-64) shared how her friend fell while helping her clean the basement, and that friend broke her arm and had to go to the hospital (this last example was not included in the statistics of this thesis).

## Days off Work

Out of the flooded households that had at least one working member (n=45), **56% (n=25) had a household member take time off work** to clean the basement or address health issues immediately following the flood event (Figure 10). On average, these households **took seven days off**. This is compared to 33% (n=15) of households that were flooded but did not take days off work and 11% (n=5) who gave no info. Seven days off work are more than 10 times the Ontario average<sup>10</sup> (Statistics Canada, 2018)

*Figure 10: Average Number of Days Off Work Per Worker for One Month in 2014 among Flooded Households in Burlington and Households in Ontario*



Several respondents mentioned that they were able to take vacation time to compensate for this time off work, but it is unclear how many people had to use their vacation and how many had to use other time (emergency leave, personal leave, or sick days, depending on the cause). Some respondents did share how taking time was difficult, reporting that they had to “scramble”.

<sup>10</sup> The author chose 2014 as this was the closest comparison to the time respondents took off following the August 2014 flood. The data from Statistics Canada was only provided on an annual basis.

Others shared how one spouse was not working, which meant that the non-working spouse could stay home and meet with contractors or do renovations.

Some of the difficulties respondents faced included:

- having to go to an important meeting in Toronto the day after the August 2014 flood and being very stressed because of the damage back home,
- stopping self-employment for several months to recuperate, and
- losing their cellphone by dropping it in the water, which made running their own business difficult as so much business was done over the phone.

As well as time off work, respondents anecdotally shared how their productivity suffered following the flood due to interruptions and stress. One self-employed respondent (aged 25-64) shared how although he did not take any full days off, “my business no doubt suffered”.

### **Property and Casualty Insurance Costs**

Out of the flooded households that shared the range of property and casualty insurance coverage they received (n=57), almost half (49%, n=28) did not have full property and casualty insurance coverage. The rest received full coverage (25%, n=14), did not submit claims (14%, n=8)<sup>11</sup>, were denied coverage (11%, n=6) or they did not know the range of coverage received (2%, n=1).

While the average cost of a flooded basement in Canada is over \$40,000 (Insurance Bureau of Canada, 2017, personal communication), some households anecdotally shared how their costs were much higher. One household shared how their property damage was over \$100,000 in damages, but that their property and casualty insurance was capped at \$30,000, and they faced

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<sup>11</sup> One respondent explained this was because their damage was small, but other households may simply have not had any insurance since all the other households that did not submit claims suffered some physical damage.

financial hardship as a result. Several respondents shared how this lack of insurance coverage was a source of worry and contributed to stress.

The reason specific costs are not available is that author speculated that respondents would be more likely to provide a range of insurance coverage than a specific amount. Some people may be uncomfortable sharing specific financial information, but for this thesis, 98% (57 out of 58) of respondents from flooded households answered this question.

## 6.0 Discussion

This section addresses each of the research questions of this thesis.

### **1. Short-term and Long-term Mental and Physical Health Impacts Associated with Residential Basement Flooding**

This thesis found significant mental health impacts associated with residential basement flooding in the 30 days following a flood, and for at least three years thereafter. Similar findings have been reported in the referred literature (Azuma, Ikeda, Kagi, Yanagi, Hasegawa & Osawa, 2014; Chae, Tong, Rhee & Henderson, 2005; Fernandez et al., 2015; Lamond et al., 2015; Malthais, Robichaud & Simard, 2000; Mason, Andrews & Upton, 2010; Tunstall et al., 2006; Waite, Chaintarli, Beck, Bone, Amlôt, Kovats, Reacher et al., 2017).

Many of the challenges associated with residential basement flooding occur within the first month:

- households must contact their insurance provider and wait to confirm whether their insurance covers the damages,
- they must address the flooding by removing water and impacted items themselves and /or with the help of contractors, and
- they may experience worsening of existing health issues.

For all these reasons, it is logical that the results indicate the first month of experiencing a flood is the most stressful.

The fact that almost half of respondents were still worried three years after a flood event is supported in the global refereed literature (Lamond et al., 2015; Tunstall et al., 2010; Waite, Chaintarli, Beck, Bone, Amlôt, Kovats, Reacher et al., 2017) and suggests that there may be a need for mental health support – counselling and therapy available for flood survivors – beyond

the first several months following a flood event. It also suggests that communities that have experienced flooding may be receptive to flood mitigation action to alleviate mental stress.

Worry and stress can exacerbate other health impacts (Alderman et al., 2012; Ginexi, Weihs, Simmens, & Hoyt, 2000; Reacher et al., 2004), so it is possible that this long-term worry in reference to flooding could lead to additional physical health impacts. The physical manifestations of this stress for those who have experienced flooding can include headaches and difficulty sleeping (Alderman et al., 2012; Hutton, 2004; Lamond et al., 2015) and heart palpitations (Chae et al., 2005), or all three (Chae et al., 2005; Tunstall et al., 2006).

While the thesis did not find any significant increases in physical health impacts among flooded households, it is possible that some respondents may have simply not remembered seemingly small health impacts such as skin irritations. As well, stomach cramps are associated with gastrointestinal illnesses that may result from contact with water contaminated with fecal matter or agricultural run-off (Du et al., 2010; Wade et al., 2004). Not all flooding in the basements profiled in this study was caused by sewer back-up, and for those affected by overland flooding, it is unknown how much water may have been contaminated. As well, 40% of respondents from flooded households claimed they took precautions when cleaning up, such as using gloves and boots, to ensure they did not come into contact with the potentially contaminated water.

Further research may elucidate why members of non-flooded households experienced greater breathing difficulties. One hypothesis is that air quality may have been poorer in the non-flooded households due to mould - many houses that experienced flooding could have been cleaned so well that mould growth may have been minimized. Conversely, the homes that had not experienced flooding may have had mould because they had never undergone a similar cleaning process. Further research would be needed before any conclusions can be drawn. The refereed literature has found a correlation between flooded households and a higher incidence of breathing difficulties (Ahmed et al., 2011; Biswas et al., 1999; Collins et al., 2013; Kunii et al.,

2002; Milojevic et al., 2011; Reacher et al., 2004; Tunstall et al., 2006). However, this correlation would depend on a variety of factors such as how well the house was cleaned and how long water and wet items remained in the house post-flood.

In summary, the thesis found significantly higher mental health impacts among flooded households in the short-term and long-term. Further research could glean insight on why non-flooded households experienced significantly higher breathing difficulties.

## **2. Attributes affecting vulnerability to mental and physical health impacts**

This thesis found several attributes that significantly correlated with the worry and stress that flooded households experienced. Age (adults aged 25-64 years and seniors  $\geq 65$  years), water height in the basement, difficulty contacting an insurance provider, and worsening of existing health issues were all significantly correlated with higher worry and stress. Attributes such as gender, socio-economic status, and lack of social support were inconclusive.

**Age:** The thesis found that adults (25-64 years) and seniors ( $\geq 65$  years) experienced significantly higher worry and stress than the adults and seniors in the non-flooded households. Both had to manage the clean-up process and many were caregivers for children and/or spouses. The impact on children may have been under-reported, as no child was subject to interviews – all respondents in this thesis were 18 years of age or older. It is possible that children exhibited their worry and stress in ways that adults were not aware of.

For seniors, the academic literature suggests that they exhibit higher worry and stress following flood events. This age group may be particularly vulnerable to the health impacts of flooding (Alderman et al., 2012; Collins et al., 2013; Lowe et al., 2013) due to a range of factors such as compromised health systems (Burton et al., 2016) or reliance on others to move them to safety. They may also rely on medical services that can become disrupted during flooding, increasing the risk of developing health issues or worsening existing ones (Alderman et al., 2012; Lowe et

al., 2013). However, some seniors in this thesis who did not exhibit worry and stress echoed the study by Hutton (2004) that showed seniors may exhibit a higher psychological self-sufficiency compared to younger generations.

**Gender:** The role that gender played in reference to health impacts was inconclusive in this thesis. Females and males were equally worried in the first month of flooding, suggesting that both are comfortable admitting the first month was a stressful time period.

While the thesis demonstrates that females in flooded households exhibited significantly greater worry and stress in the long-term, it is possible that women were more comfortable discussing their worry and stress compared to men. It is possible that male respondents were also worried when it rains, but that this manifested itself in different ways, or they were less willing to share their stress levels due to social desirability bias. Mental health is still a source of stigma for many, particularly for men. An anonymous, online survey administered to the same group and with all other variables the same could test the possibility that men also experience long-term worry and stress, but that they were less inclined to share this in person with the author.

These inconclusive findings are consistent with the literature. Some studies have found women are at greater risk of exhibiting mental health symptoms (Lowe et al., 2013; Mason et al., 2010; Paranjothy et al., 2010), they report worse overall health in the aftermath of a flood (Alderman et al., 2013), and they are twice as likely to purchase new drugs for mental health challenges following a flood (Motreff, Pirard, Goria, Labrador, Gourier-Frery, Nicolau, et al. 2013). However, other studies have found “contradictory evidence” on the impact of gender on health impacts (Fernandez et al., 2016, p.9).

### **3. Water Height, Difficulties Contacting an Insurance Provider and Worsening of Existing Health Issues**

This thesis determined that these factors – water height in the basement, difficulty contacting an insurance provider, and worsening of existing health issues – correlated with higher worry and stress in the first month following a flood (Figure 9). These findings are all supported in the refereed literature.

The higher the floodwaters, the greater the potential for damages, and the greater the potential financial cost. Higher water levels also suggest that more items could have been lost, as some people shared how the water even came up into their main floor, destroying items they thought were safe from damage. These findings are supported in the literature, where greater water depth correlates with a greater risk for mental health challenges (Fernandez et al., 2015; Lamond et al., 2015; Reacher et al., 2004; Waite et al., 2017).

Being unable to contact property and casualty insurance providers, receiving unclear information, or waiting for an adjuster to visit the home to determine the insurance coverage can all add to worry and stress. One respondent, who “lost everything”, waited four days for an adjuster to visit her house in the aftermath of a flood, during which time food rotted in her basement from a capsized refrigerator. Dixon et al. (2016) also found that difficulty contacting insurance providers was one of the top three attributes that influenced vulnerability to stress following a flood (alongside difficulties with the clean-up process and rebuilding).

There are examples in the referred literature where residential flooding results in worsening of existing health issues. In their systematic review of mental health impacts from flooding, Fernandez et al. (2015) identified “existing illnesses” (p.11) as a key risk factor for mental health challenges from flooding. If a respondent had an existing health issue, recovery could be more uncertain and take longer. This could have added to stress – for instance, some respondents reported physical difficulties from cleaning up after the flood, which then made continuing the removal of wet items more difficult. Some impacts were highly traumatic - said one respondent

about an already ill family member who survived the flood - "I believe that the stress of the whole situation deteriorated their condition...they went into the hospital and never came home".

Refereed literature has also identified that those with existing mental health conditions may experience those symptoms worsen as a result of flooding (Bich et al., 2011; Ginexi et al., 2000; Hetherington, McDonald, Wu & Tough, 2017; Heo et al., 2008). Paranjothy et al. (2011) and Alderman, Turner & Tong (2013) found that having an existing medical condition increased the risk of reported psychological distress, anxiety, depression and Post-Traumatic Stress Disorder (PTSD) following a flood. The author heard how the interruption of routine caused by basement flooding exacerbated conditions such as Alzheimer's, resulting in increased levels of worry and stress for the person with the condition and their caregiver. Further research on how existing medical conditions have influenced post-flood health is necessary, as most studies in the refereed literature do not examine pre-existing medical conditions.

**Socio-Economic Background:** Further research is needed between households with different socio-economic backgrounds to determine how vulnerabilities and resulting health impacts differ, as most of the households in this thesis had similar, relatively financially affluent backgrounds compared to households in the rest of the City of Burlington, the province, and Canada. Additional research could demonstrate whether findings are applicable across geographic areas with different demographics. The literature suggests that a lower socio-economic background is an attribute that increases vulnerability to health impacts from flooding (Bubeck & Thieken, 2018; Burton et al., 2016; Collins, Jimenez & Grineski, 2013; Lamond et al., 2015).

**Social Support:** This thesis interviewed flooded respondents on "what social support did you receive" (e.g. support from friends, family, and colleagues), and some respondents shared how they relied on social support, while others shared how they did not need it. The role of social support on health outcomes in this study is inconclusive, as explored below.

For many, social support helped them in a very difficult period. Many residents shared how in response to the flooding, “the support was phenomenal” and “it really was a community that came together”. Strangers helped flooded residents by offering to do laundry and by providing meals, and one flooded family organized a community barbeque to raise funds for flood survivors. Respondents also shared how they were glad they “all got to know our neighbours better”, and how the shared stressful experience led to an ease in conversation when they met with each other.

In addition, some respondents coped through social comparison (Taylor, Buunk & Aspinwall, 1990), sharing that their situation was not as dire as someone else. This was shown in the following quotes:

- "There were more people that needed help than we did" (woman aged 25-64)
- “We were very blessed compared to some people...nobody was hurt” (woman aged 65 or older)
- We “got off lucky” compared to others in the neighbourhood (woman aged 25-64)

However, others highlighted their own self-sufficiency and reminded the author that they did not require any social support. For instance, several respondents discussed simply “getting through” the experience, expressed in the quotes below.

- “Didn’t need it [social support]. Didn’t ask for it. The flood was happening to everyone” (woman aged 25-64)
- “We're pretty self-sufficient" (man, aged 65 years or older)
- “It was hard but we managed it...you’ve got to be resilient” and “sometimes stress brings out the best in you” (woman aged 25-64)

In summary, this thesis found several attributes to vulnerability for health impacts, but additional research is needed to assess the role that gender, socio-economic background and social support has on a community that has experienced flooding.

### **Financial costs associated with residential basement flooding**

Significant financial costs identified in this thesis were days off work and lack of property and casualty insurance coverage. There were no significant differences for visits to health services and medication use between flooded and non-flooded households.

**Days Off Work:** The finding that 56% of working households took on average seven days off work on average suggests that residential basement flooding results in reduced productivity in the Canadian workforce. This reduced productivity aligns with studies that have found that ‘presenteeism’, or working while unhealthy, can have significant financial consequences (Goetzel et al., 2004). The days off work would have been higher in this thesis if the August 2014 flood had occurred in a month other than August – several respondents shared how they already had summer vacation planned or they were teachers who already had the summer off work.

**Health Service Visits and Medication Use:** It is possible that respondents may have under-reported their visits to health services (e.g. therapist or counsellor) and medication use due to perceived stigma in reference to mental health resources. Medical data and health insurance claims for flood-impacted communities would provide further clarity on the financial costs associated with the health impacts experienced.

**Property and Casualty Insurance Coverage:** One possible reason why property and casualty insurance did not cover damages for some of the respondents was that at the time of the major flooding in August 2014, overland flood insurance was not offered in Canada (it is now offered

by most major property and casualty insurance providers). Overland flooding “occurs when bodies of water, such as rivers, dams overflow onto dry land” (Insurance Bureau of Canada, 2017a). This is compared to flooding from sewer water back-up, which occurs when sewer systems become overwhelmed and water flows into basements from sanitary sewer lines. During the August 2014 flood, households in Burlington experienced both overland and sewer back-up flooding, which may have led to some households being denied coverage.

## **Summary**

This thesis has identified health impacts of residential basement flooding in Canada, and associated financial costs, including time off work. The thesis found that there are significant mental health impacts both immediately following a flood event (in the first 30 days) and in the long-term (approximately three years later), and that the following all correlate with higher reported worry and stress:

- a person’s age,
- height of flood water in basement,
- difficulty contacting an insurance provider in the aftermath of flooding, and
- worsening of existing health issues

The associated financial costs of flooding include an average of seven days off work, reducing productivity for workers.

Building on this thesis, logical next directions in research could be directed to examine medical data and health claims in communities affected by flooding to further explore the financial costs resulting from physical and mental health impacts of residential basement flooding. In addition, replication of the study in a flooded but less financially affluent community would explore how vulnerabilities and resulting health impacts differ, providing information for health providers to tailor messaging and response. If the replication of this study demonstrates that there are even

more severe health impacts in less financially affluent communities, this suggests that the findings may have broad-based applicability across communities of different socio-economic backgrounds.

As flooding increases in frequency and severity in Canada in the years ahead (Insurance Bureau of Canada, 2017a), the findings from this thesis provide added rationale and urgency to mitigate residential flood risk in Canada. If action is not taken to reduce this risk, the mental health impacts profiled in this thesis will likely worsen as greater numbers of homeowners across Canada experience the “nightmare” that is residential basement flooding.

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## Appendix A: Interview Questions with Flooded Households

### 1. At the time you had water in your basement, who made up the members of your household?

You can circle these age ranges and the sex of the different members. If you prefer not to list the sex and age range of members of your household you do not have to answer these questions.

Household Member 1	Household Member 2	Household Member 3	Household Member 4	Household Member 5
Male / Female				
<5 years old				
6-14 years old				
15-24 years old				
25-64 years old				
65 years old+				

- Prefer Not to Answer
- Don't Know
- 

### 2. Did you or any members of your household receive any guidance on how to clean up your basement?

YES	NO	Don't Know	Prefer Not to Say
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[IF YES] What guidance was it, and was it useful?

### 3. Who was physically present to help clean up your basement?

- Yourself
- A member of your household
- A friend

- A contractor
- Don't know
- Prefer Not to Answer

4. (If answered "Yourself" or "A member of your household"): **Did you or any members of your household take any precautions during clean-up of your basement?** [if person needs clarification, say "This may include, but is not limited to: wearing rubber boots when walking in the water, or wearing goggles, or a breathing mask. Things like that.]

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **What was this?**

5. **How long did it take to have all the water and all the items that got wet removed from your basement?**

	Don't Know	Prefer Not to Say
--	------------	-------------------

6. **Was your basement finished when it had water in it?**

YES	SOMEWHAT	NO	Don't Know	Prefer Not to Say
-----	----------	----	------------	-------------------

Now I have a couple of questions about insurance.

7. **How much of the water damage was covered by your insurance?**

None	Less than half	More than half	Don't Know	Prefer Not to Say
------	----------------	----------------	------------	-------------------

8. [If covered at least partly] **How long did it take to process your claim?**

- Within 3 months
- Within 6 months
- Within a year

- Over a year
- Still ongoing
- Don't Know
- Not applicable
- Prefer Not to Answer

**9. Did you have any difficulty contacting your insurance company?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **What was the difficulty that you had?**

**10. What social support did you receive?**

HEALTH: Now I am going to ask you a series of questions about your health.

**11. Within the first month of experiencing water in your basement, did you or any members of your household experience difficulties sleeping? If so, why?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **Which household member was affected?**

**12. Anytime since, have you or any members of your household experienced difficulties sleeping?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **What caused the difficulty sleeping?**

[IF YES] **Which household member was affected?**

**13. Within the first month of experiencing water in your basement, did you or any members of your household experience breathing issues you had not experienced before having the water in the basement?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**14. Anytime since, have you or members of your household experienced breathing issues that you had not experienced before the water in the basement?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**15. Within the first month of experiencing water in your basement, did you or any members of your household experience stomach cramps?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**16. Within the first month of experiencing water in your basement, did you or any members of your household experience skin rashes?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**17. Within the first month of experiencing water in your basement, did you or any members of your household experience worsening of health issues that had already existed at the time your basement had water in it?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **Which household member was affected?**

**18. Anytime since, have you or any members of your household experienced worsening of health issues that had already existed at the time your basement had water in it?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[If yes] **What was it?**

[IF YES] **Which household member was affected?**

**19. Within the first month of experiencing water in your basement, did you or any members of your household experience worrying and stress beyond the normal and everyday? (If the participant asks for a definition then can clarify: "worrying and stress beyond the normal and everyday is worrying and stress that interferes with your regular day to day activities")**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **Which household member was affected?**

**20. Anytime since, have you or members of your household experienced worrying and stress beyond the normal and everyday?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **Which household member was affected?**

**21. On a scale of 1-5, how worried do you or any members of your household get when it rains? 1 is not worried at all, and 5 is very worried.**

	Don't Know	Prefer Not to Say
--	------------	-------------------

**[IF YES] Which household member is affected?**

Script: Now I am going to ask you a series of questions about actions you may have taken in response to the health impacts described above.

**22. Did you or any members of your household take time off work to deal with any of these health issues, or to deal with the health issues of other members of your household, or to clean up the basement?** (If participant asks for clarification: "this could involve taking time to go to a medical appointment, or taking time to bring a child to a medical appointment")

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

**23. [If "Yes" to above] Did this cause any difficulties for you?**

YES	SOMEWHAT	NO	Don't Know	Prefer Not to Say
-----	----------	----	------------	-------------------

**[IF YES] What were they?**

**[IF YES] 24. How many approximate days did you or members of your household take off?**

**(skip to PAGE 12 (question 34) if there were no health impacts identified)**

**25. During and since your basement had water in it: Did you or any members of your household begin taking medication or increase your medication to deal with any of these health issues?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**26. During and since your basement had water in it: Did you or any members of your household begin or increase visits to the following to deal with any of these health issues?**

- **27. A therapist or counsellor?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

- **28. A family doctor?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

- **29. A hospital?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

- **30. A walk-in clinic?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**31. During and since your basement had water in it: Were there any other health services that you or members of your household visited to deal with these health issues? If yes, please specify what they were.**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**32. Are there any other ways your health or the health of a member of your household might have been impacted by the water in your basement that you'd like to mention?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**33. Were there any other situations or events going on around the same time as the water in your basement you feel could explain some of the health impacts?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

**34. Have you or any members of your household noticed visible mould or mildew in your basement or other parts of your home?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

**35. Have you or any members of your household detected the smell of mould or mildew in your basement or other parts of your home?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

Almost done! Now I have several brief demographic questions purely for statistical purposes.

**36. At the time of the water in your basement, did you own or rent?**

OWN	RENT	Don't Know	Prefer Not to Say
-----	------	------------	-------------------

**37. How long have you lived in this house?**

**38. We would like to know your combined household income level, for statistical purposes only.**

**Please select your income range.**

- Under \$49, 999
- \$50,000 - \$59, 999
- \$60,000 - \$69, 999
- \$70,000 - \$79, 999
- \$80,000 - \$89, 999
- \$90,000 - \$99, 999
- \$100,000 - \$124,999
- \$125,000 or more
- I don't want to share \_\_\_\_\_
- Don't know\_\_\_\_\_

**39. What is the highest level of education you have obtained?**

- No certificate, diploma or degree
- High school diploma or certificate
- Apprenticeship or trades certificate or diploma
- College, CEGEP or other non-university certificate or diploma
- University certificate or diploma below bachelor level

- Bachelor's degree
- University certificate, diploma or degree above bachelor level
- Prefer Not to Answer
- Don't Know

**40. (If applicable) And the highest level of education your partner/spouse has obtained?**

- No certificate, diploma or degree
- High school diploma or certificate
- Apprenticeship or trades certificate or diploma
- College, CEGEP or other non-university certificate or diploma
- University certificate or diploma below bachelor level
- Bachelor's degree
- University certificate, diploma or degree above bachelor level
- Prefer Not to Answer
- Don't Know

## Appendix B: Interview Questions with Non-Flooded Households

**1. Who currently makes up the members of your household? You can circle these age ranges and the sex of the different members.** If you prefer not to list the sex and age range of members of your household you are free not to answer these questions.

Household Member 1	Household Member 2	Household Member 3	Household Member 4	Household Member 5
Male / Female				
<5 years old				

6-14 years old				
15-24 years old				
25-64 years old				
65 years old+				

- Prefer Not to Answer
- Don't Know

**2. Have you or any member of your household received any guidance on how to clean up your basement after a flood? If so, please specify what this guidance is.**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **What guidance was it, and was it useful?**

Now I am going to ask you a series of questions about your health.

**In the last three years, have you or any member of your household ever experienced:**

**3. Skin rashes?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **Which household member was affected?**

**4. Difficulties sleeping at night?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] **Which household member was affected?**

**5. Worsening of existing health issues?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**6. New breathing issues?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**7. Worrying and stress beyond the normal and everyday?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**In the last three years:**

**8. On a scale of 1-5, how worried do you or any members of your household get when it rains? 1 is not worried at all, and 5 is very worried:**

	Don't Know	Prefer Not to Say
--	------------	-------------------

[IF YES] Which household member was affected?

**9. Did you or any members of your household begin taking medication or increase your medication?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**10. Did you or any members of your household begin or increase visits to a therapist or counsellor?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**11. Did you or any members of your household begin or increase visits to a family doctor?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**12. Did you or any members of your household begin or increase visits to a walk-in clinic?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

**13. Did you or any members of your household begin or increase visits to a hospital?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

14. Did you or any members of your household begin or increase visits to other health services not mentioned above? If yes, please specify what services you went to.

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

15. Are there any other ways your health or the health of a member of your household has been impacted in the last three years? If yes, please specify in what ways:

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

[IF YES] Which household member was affected?

16. Were there any situations or events going on in the last three years that you feel could explain some of the health impacts?

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

17. Have you or any members of your household noticed visible mould or mildew in your basement or other parts of your home?

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

**18. Did you or any members of your household detect the smell of mould or mildew in your basement or other parts of your home?**

YES	NO	Don't Know	Prefer Not to Say
-----	----	------------	-------------------

**Script: Now I have several brief demographic questions purely for statistical purposes.**

**19. Do you own or rent?**

Own	Rent	I Don't Want to Share	Don't Know
-----	------	-----------------------	------------

**20. How long have you lived in this house?**

**21. We would like to know your combined household income level, for statistical purposes only.**

**Please select your income range.**

- Under \$49, 999
- \$50,000 - \$59, 999
- \$60,000 - \$69, 999
- \$70,000 - \$79, 999
- \$80,000 - \$89, 999
- \$90,000 - \$99, 999
- \$100,000 - \$124,999
- \$125,000 or more
- I don't want to share \_\_\_\_\_

- Don't know\_\_\_\_\_

**22. What is the highest level of education you have obtained?**

- No certificate, diploma or degree
- High school diploma or certificate
- Apprenticeship or trades certificate or diploma
- College, CEGEP or other non-university certificate or diploma
- University certificate or diploma below bachelor level
- Bachelor's degree
- University certificate, diploma or degree above bachelor level
- Prefer Not to Answer
- Don't Know

**23. (If applicable) And the highest level of education your partner/spouse has obtained?**

- No certificate, diploma or degree
- High school diploma or certificate
- Apprenticeship or trades certificate or diploma
- College, CEGEP or other non-university certificate or diploma
- University certificate or diploma below bachelor level
- Bachelor's degree
- University certificate, diploma or degree above bachelor level
- Prefer Not to Answer
- Don't Know

## Appendix C: Attributes Hypothesized to Correlate with Worry and Stress

Below is a list of attributes that the author hypothesized would positively correlate with worry and stress in the first month of flooding. These attributes were identified in the refereed literature.

*Table 4: Attributes Hypothesized to Positively Correlate with Worry and Stress among Flooded Households in Burlington, Ontario*

<b>Attribute</b>	<b>Metric</b>	<b>Hypotheses</b>
Water height	Water height was >1 foot (30 cm) high	The higher the water level, the greater the potential for physical damage and resulting financial cost.
Time for water to be removed	Removed after 24 hours	The greater the amount of time it took to remove items, the greater the amount of time mould had to grow and the longer the respondent had to worry in reference to resulting health impacts.
Time for items that got wet to be removed	Removed after 24 hours	Same as above.
Insurance coverage (Property and Casualty)	Insurance covered half or less than half of total damages	Households were property and casualty insurance covered half or less than half of all damages would theoretically pay for the rest themselves or find alternative sources, potentially resulting in financial hardship.
Difficulty contacting insurance provider	Yes	If households experienced difficulty contacting insurance providers, this may have created additional stress due to uncertainty around coverage and waiting for an adjustor.

Time to process claim	Over one month	The longer it took to process a claim, the greater the uncertainty for the respondents, and the more the respondent might have had to pay for the cost of damages themselves upfront.
No social support	Yes	Social support can act as a buffer against stress. No social support can be a risk factor for negative health outcomes (Bei et al., 2013, Gordon, Bresin, Dombeck, Routledge & Wonderlich, 2011; Tunstall et al., 2006).
Other events at same time as flood	Yes	If there were other events occurring at the same time, this could suggest added stress. For instance, some respondents shared that they dealt with the flood at the same time that they were looking after aging parents who were also flooded.
Existing health issues worsened	Yes	Existing health issues can complicate recovery and increase risk of Mental health challenges (Fernandez et al., 2015).
Basement was finished	Yes	Finished basements would require greater financial resources to refurbish.
Lost personal items	Yes	If there were personal items lost, then the respondent could have experienced a greater sense of loss than if no personal items were lost. The greater the loss, potentially the greater the emotional toll on the respondent.

## Glossary

Topic	Definition
Health Impacts	“Health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity” (WHO, 2018).
Health System Impacts	Visits to health services (e.g. visits to family doctors, hospitals and walk-in clinics) and new or increased medication use. Damages to physical infrastructure caused by flooding were out of scope for this thesis.
Flooding	Residential basement flooding (overland or sewer back-up). This thesis does not include flooding to commercial properties.
Flood Mitigation	“A sustained action taken to reduce or eliminate long-term risk to people and property from flood hazards and their effects. Mitigation distinguishes actions that have a long-term impact from those that are more closely associated with preparedness for, immediate response to, and short-term recovery from specific events” (Moudrak & Feltmate, 2017).
Flood Risk	“Flood risk is a combination of the likelihood of occurrence of a flood event (flood frequency) and the social or financial consequences of that event when it occurs (through exposure to the flood hazard)” (Moudrak & Feltmate, 2017).
Mental Health	“a state of well-being in which every individual realizes his or her own potential, can cope with the normal stresses of life, can work productively and fruitfully, and is able to make a contribution to her or his community” (World Health Organization, 2018). Physical and mental health are closely interconnected.
Physical Health Impacts	Physiological impacts, such as breathing difficulties. Physical and mental health are closely interconnected.
Stress	An “emotional experience accompanied by predictable biochemical, physiological and behavioral changes” (Baum, 1990)
Vulnerability	The susceptibility of “a system's attribute(s) of concern to a hazard (in temporal reference)” (Füssel, 2007). This framework recognizes there are four attributes required for an understanding of vulnerability – the system (e.g. social or geographic), the attributes of concern (e.g. human health, culture, or biodiversity), the hazard itself (e.g. flooding), and a temporal reference (the “point in time or time period of interest” (p.6)).