International Journal of
Disaster Management
ISSN: 2527-4341

RESEARCH ARTICLE   **Open Access**

Are We Prepared for the Next Disaster? Evidence from Ice Storm

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Abstract

This study examines the impacts that an emergency had on people's preparedness levels, using the December 2013 Ice Storm in the Greater Toronto Area (GTA) as a case. A questionnaire consisting of three sections was developed to measure the associated impacts, people's reactions/opinions, as well as their preparedness levels before and after the ice storm. The goal of the research is not only to discuss the factors that influenced people's ability to prepare, respond to and recover from the ice storm but also to generate useful insights for future disasters that are similar in nature. Our analysis includes various aspects such as the effectiveness of advance warnings and their ability to disseminate information to mass audiences. The findings show that, most of the respondents believe that they learned a lot about ice storms and their impacts because of their prior experience; a significant majority believe that it is the city's/municipality's responsibility to prepare for emergencies like ice storms; home ownership was significantly associated with the previous ice storm preparedness; and, power outage experience was significantly associated with the next ice storm preparedness.

Keywords: ice storm; disaster preparedness; emergency supplies; disaster experience; Greater Toronto Area (GTA)

Introduction

Ice Storm, aka *Silver Storm*, is a "storm characterized by a fall of freezing liquid precipitation" (American Meteorological Society, 2020). The December 2013 Ice Storm (December 20-23) was one of the worst natural hazards to hit Southern Ontario (Canada), particularly the Greater Toronto Area (GTA). While the Government of Canada issued a series of freezing rain warnings for the affected areas on December 19 through different channels (Kitching, 2013), the complexity of the event made it challenging to accurately forecast and broadcast the associated details. The epicentre of the freezing rain was along the northern coast of Lake Ontario (GTA included), which saw as much as 30 mm of ice accumulation (Environment and Climate Change Canada, 2020), a two-year supply in only two days. Damage to power lines resulted in more than 600,000 households losing power when the ice storm started (Government of Ontario, 2013). By the time it ended, as many as 830,000 hydro customers (around 2.5 million individuals) across Southern Ontario had experienced power outage for several days (Public Safety Canada, 2020). In addition to power distribution issues, the ice storm caused substantial damage to plants and trees. For example, the City of Toronto, one of the hardest-hit areas, lost approximately 20% of its tree canopy (Oved, 2013). Moreover, the ice storm generated huge amounts of debris in the form of broken power poles, power cables, trees, homes, buildings, and vehicles. Some highways and streets were closed due to debris and/or unavailability of traffic control systems and traffic lights (Coutts, 2014). The lack of power, icy roads, and debris kept most people at home.

The ice storm also led to an increase in hospital emergency department presentations for acute injuries (due to falls, motor vehicle collisions, and other factors) as well as other severe weather-related illnesses (e.g. gastrointestinal illness, cold-related injuries, acute cardiovascular events, respiratory illness, and acute psychiatric

illnesses) (Rajaram et al., 2016). While two major hospitals in Toronto had to use backup generators (Armenakis & Nirupama, 2014), the City of Toronto opened 13 emergency reception centres, the largest emergency social services response in its history (Office of Emergency Management - Toronto, 2015). Also, Toronto Fire Services received 316 calls for carbon monoxide (CO) exposures, and Emergency Medical Services received 1,100 calls (over 60% higher than previous years) for general medical issues, slips and falls, and CO exposures. A similar remarkable increase in fire and rescue responses was observed in the City of Vaughan (north of Toronto) (Sabet et al., 2019), which imposed a lot of pressure on fire stations given the unfavourable road conditions. Lack of indoor heating, use of inappropriate alternative heating sources, running power generators in enclosed spaces, food contamination due to lack of refrigeration, slippery sidewalks due to ice accumulation, falling ice from buildings and tree debris, and downed live power lines were among the main associated secondary hazards that led to the aforementioned increases in emergency calls (Rajaram et al., 2016).

The economic impacts (e.g. loss of jobs and revenue) were also significant due to the interruption of business activities and operations in the pre-Christmas season. According to the Canadian Disaster Database (CDD), federal, provincial/territorial, and municipal costs associated with the ice storm exceeded $260 million (Public Safety Canada, 2020). Further, local airports including Toronto's Pearson International Airport experienced substantial flight delays and cancelations (Shum, 2014) and Canada Post could not deliver mail during the most important business week of the year (Gallant, 2014). Although many people had travel plans during the Christmas holidays, the ice storm left them stranded.

While the 2013 Ice Storm caused a lot of disruption, many lessons can be learned from this event such that individuals, families, businesses, government agencies, and the community (as a whole) become more prepared for similar events in the future. Given that ice storm is a natural hazard that cannot be effectively prevented from happening, risk management efforts should be directed toward minimization of the associated impacts by developing mitigation plans, adopting preparedness activities, and implementing effective and timely response/recovery measures. Some cities in the impacted areas have already changed/updated their emergency response plans. For instance, Toronto's emergency response strategy has been modified by identifying several permanent emergency reception centres, improving electric power lines, enhancing protection measures for vulnerable residents, and developing new emergency communication methods. Also, Toronto Hydro (the main electricity distribution system operator in Toronto) and the city's forestry division have updated tree clearing practices to cut down on the number of power lines at risk, and they have been planning to shift to more resilient infrastructure (PwC, 2014). Raising public awareness is another important factor to reduce the impacts of similar events in the future. People are often unaware of the hazards and their associated risks in their surroundings until a disaster event like ice storm occurs (Coppola, 2011). Access to accurate risk information is a first step with regard to risk recognition and awareness; hence, communicating the risks to the affected population could play a crucial role towards enhanced awareness, and in turn, potentially improved preparedness (World Economic Forum, 2011).

The 2013 Ice Storm in Southern Ontario provided an opportunity for experiencing, learning useful lessons for future events, and creating more resilient as well as better-prepared communities. The main goal of this study is to understand if this major event has enhanced people's awareness and preparedness for this kind of emergency. More specifically, we are interested in examining how different individuals and families were influenced by this event, how much knowledge they gained from that experience, and if this emergency impacted their preparedness decisions and actions for upcoming similar events. For data collection, we designed a questionnaire survey, which was completed by 865 individuals who live in the GTA and its surrounding towns.

Our findings show among other things that a significant portion of the households were not prepared for the December 2013 Ice Storm; most of the respondents believe they learned a lot about ice storms and their impacts

because of their prior experience; and, home ownership was significantly associated with ice storm preparedness. The rest of the paper is organized as follows: The next section reviews the most relevant literature, then, we describe our data collection method and provide some sociodemographic statistics. The section following this presents our data analyses and key findings. Finally, conclusions are discussed in the last section of this paper.

Literature Review

Disasters are opportunities in disguise. They can expose unknown vulnerabilities, increase public awareness and public education campaigns, enhance people's experiences, foster disaster and emergency plans and policies, and provide opportunities for building more resilient communities (Coppola, 2011). The existing literature includes numerous studies on disaster preparedness at the individual, household, and/or community levels. However, given the focus of this study and for a better organization of the contents, we review the literature under the following (inter-related) streams: disaster preparedness and community engagement; preparedness and sociodemographic factors; risk communication and public awareness; and, disaster experience and relationship with preparedness.

Disaster preparedness and community engagement

Disaster preparedness consists of measures that enable individuals, households, organizations, communities, and societies to respond more effectively to and recover more quickly from disasters (Sutton & Tierney, 2006). Effective citizen and community preparedness can save lives and reduce pressures on response organizations during major emergencies (Florida Division of Emergency Management, 2020), allowing them to help more vulnerable and special-needs residents who are unable to take care of themselves. Some researchers emphasize the importance of building local capacity and reducing community vulnerability in the context of what is known as Community-based disaster preparedness (CBDP) (Allen, 2006; Troy, Carson, Vanderbeek, & Hutton, 2008; Suryadi et al., 2021). The evolution of community-based and local-level approaches to disaster risk management as well as their future are discussed in Maskrey (2011). Chandra et al. (2013) discuss opportunities for engaging communities in disaster preparedness and recommend strategies toward community resilience using levers such as developing partnerships between government and non-governmental organizations, educating the public about disasters by providing ongoing information, and promoting participatory decision-making. Although some studies have reported mixed results, most community engagement methods seem to contribute to increased preparedness; we invite the reader to consult Ryan et al. (2020) for a recent review of the community engagement role in disaster preparedness.

Preparedness and sociodemographic factors

Several studies have shown the impacts of various sociodemographic factors on individual and family disaster preparedness. It is important to note the various differences among these studies, such as the context-dependent differences, which have led to inconsistent findings across them in certain areas (Kohn et al., 2012). In his study of hurricane impacts in Florida, Baker (2011) finds that household preparedness in the aftermath of hurricanes is strongly related to income, home ownership, age, and type of housing. In a more focused study (Alabama), residents in the lowest income quartile were found to be less likely to have a family emergency plan or emergency kit (Phillips et al., 2005). Centers for Disease Control and Prevention's (CDC) (2012) study of household emergency preparedness in 14 states in the United States (through a phone survey during 2006-2010) indicates that, despite variation among the states, in general, men are more likely than women to report that their households are prepared. Further, the study shows an increased level of preparedness among older adults, those with higher education, as well as the English-speaking population (in comparison to Spanish speakers). Basolo, Steinberg, & Gant (2017) find that age and home ownership have positive, and immigration status has negative impacts on disaster preparedness. Garingan (2021) shows that disaster preparedness is affected by age, civil status, ethnic affiliation, and occupation.

Risk communication and public awareness

Pre-disaster risk communication is a key aspect of truly effective community preparedness and response (Perry et al., 2001; Montz, Tobin, & Hagelman, 2017). Tanaka (2005) compares people's readiness for earthquakes, where the results indicate that educational sources, disaster awareness, knowledge about the neighborhood, and past disaster experiences contribute to disaster preparedness.

While public education can be potentially helpful in raising awareness, the approach by which the public is educated about preparedness measures must be carefully chosen to ensure that the message is received and understood by the public. A recent study surveying a sample of the US adult population shows that individuals are actually more likely to depend on friends and family rather than government organizations to receive critical information and prepare for natural disasters (Tyler & Sadiq, 2018). Setiawan et al. (2020) investigate a model of disaster preparedness schools in Indonesia and propose an Analytic Hierarchy Process (AHP) approach to develop knowledge and attitude assessment tools. A survey of Australians in New South Wales (Cretikos et al., 2008) indicates that emergency radio networks form an important emergency communication tool during disasters, especially when electricity services are interrupted. A more recent study focusing on urban disaster preparedness of Hong Kong residents (Lam et al., 2017) showed that the majority of people rely on television as a key information source both before and during disasters; while elder residents favored television and radio, young residents preferred social media and the internet. Technology, especially mobile technology, is increasingly pervasive and it is not surprising that social media is becoming the leading source of information regarding hazards and their associated risks for a significant portion of the world population.

Disaster experience and relationship with preparedness

In general, studies conducted in different settings to evaluate the relationship between disaster experience and preparedness have not all resulted in similar discoveries. Becker, Paton, Johnston, Ronan, & McClure (2017) find that experience could motivate the earthquake preparedness process through several factors such as raising awareness, understanding the disaster's consequences, and prompting community interaction on disaster issues. In an empirical study in Houston, Chen, Banerjee, & Liu (2012) use data from two cross-sectional surveys before the hurricane Ike (2008) and after the hurricane (2009) to report no significant changes in preparedness or evacuation plans; they attribute the unchanged preparedness levels to "ceiling effects", i.e. the already high levels of preparedness reported by Houston residents. Joerin, Shaw, Takeuchi, & Krishnamurthy (2012) compare two communities in Chennai (India) using a household survey and observe that prior experience to flood-related disasters does not necessarily lead to improved coping capacity. In another study, Kapucu (2008) investigates hurricane preparedness of Central Florida residents and concludes that households can be complacent in response to disasters, even if they have had a significant level of prior experience; experience could even potentially contribute to biased beliefs such as self-efficacy (Bandura et al., 1999) and unrealistic optimism (Sharot et al., 2011; Paton, 2019).

There is a broad literature on theories of disaster preparedness which include experience as one of the many factors contributing to preparedness level. For example, Protective Action Decision Model is a framework that models people's responses to environmental hazards/disasters through several stages, i.e., environmental and social context, psychological processes, situational impediments and facilitators, and feedback (Lindell & Perry, 2003; Lindell & Perry, 2012). Community Engagement Theory (Paton, 2008, 2013) is another theoretical framework which integrates variables at individual, social, and institutional system levels. Finally, we cite Protection Motivation Theory (Rogers & Prentice-Dunn, 1997; McCaughey et al., 2017) which involves threat appraisal and coping appraisal evaluations, and note that experience is considered as one factor among many others in these models. We invite the reader to consult Paton (2019) for a more comprehensive review of the psychological theories on disaster preparedness.

Data and Methods

A questionnaire consisting of three sections was designed and used for data collection. Section 1 pertained to questions regarding the respondent's experience and level of preparedness during the December 2013 Ice Storm. The first set of questions in this section were of the polar question type (*Yes* or *No*), with follow-up questions regarding the number of days without power or displaced in case respondents had experienced any impact. In the second set of questions in this section, respondents were asked about their preparedness levels for the ice storm using a Likert scale (*Strongly Disagree*, *Disagree*, *Neutral*, *Agree*, and *Strongly Agree*). Section 2 aimed to measure the extent to which the respondents were able to take and learn lessons from the December 2013 Ice Storm in preparation for future ice storms. Questions in this section were also on a Likert scale. Finally, Section 3 consisted of questions to collect some sociodemographic characteristics of the respondents, such as family size and level of education. Data were collected during the winter of 2015 and spring of 2016. In total 865 individuals from various parts of the GTA and surrounding towns completed the questionnaire based on their self-assessment. Respondents were recruited using convenience sampling and as such, they may not perfectly represent the whole population. Our data analysis methods include descriptive analysis and bivariate Chi-square tests, which we will discuss in more detail in the next section.
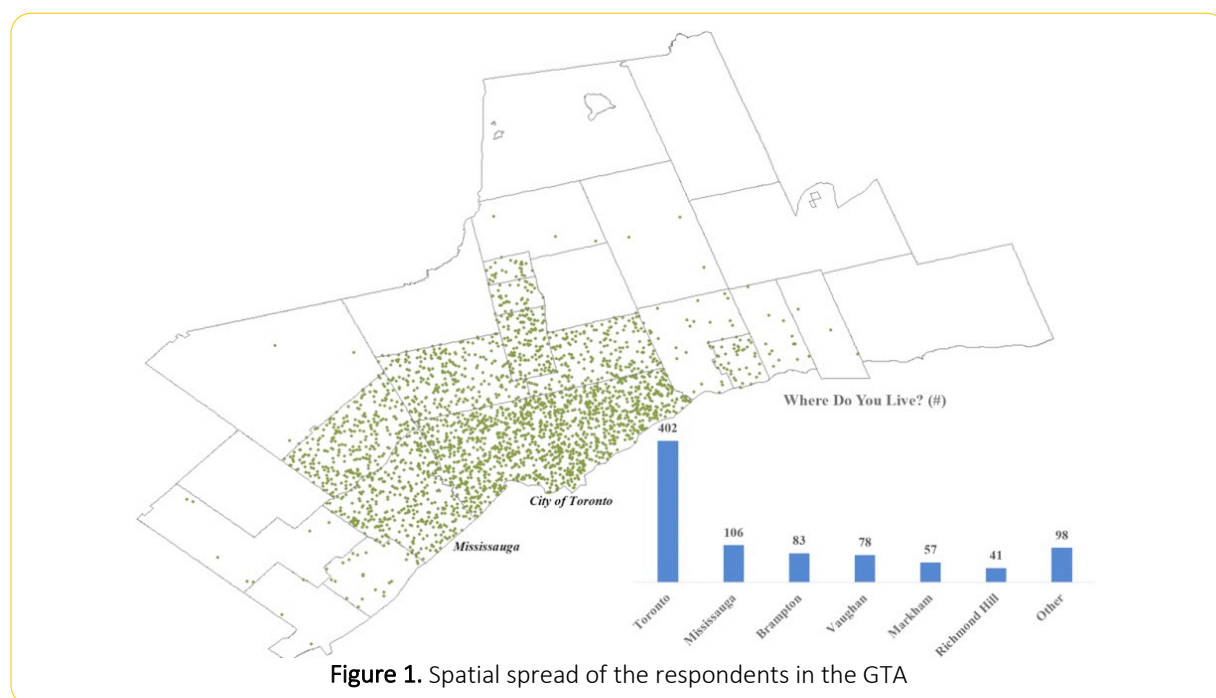

Figure 1. Spatial spread of the respondents in the GTA

More than 95% of the respondents resided in the GTA, the majority of whom (≈ 60%) lived in Toronto or Mississauga (Fig. 1), the two most populous cities in the GTA. Also, almost half of the respondents reported that they had lived in their city/municipality for 10 years or more (Fig. 2).

406 respondents (≈ 47%) were male and 457 respondents (≈ 53%) were female. In terms of family size, 43.66% of the respondent households had 3 or less, and 56.34% had 4 or more family members (Table 1).

The majority of the sample population had neither children below 12 years old (≈ 79%) nor elderly members over 65 years old (≈ 83%). Among the respondents, about 7% had family members with disabilities or special needs and therefore reliant on others. Also, around 30% of the households had pets in their houses.

Table 1. Family size reported by the respondents

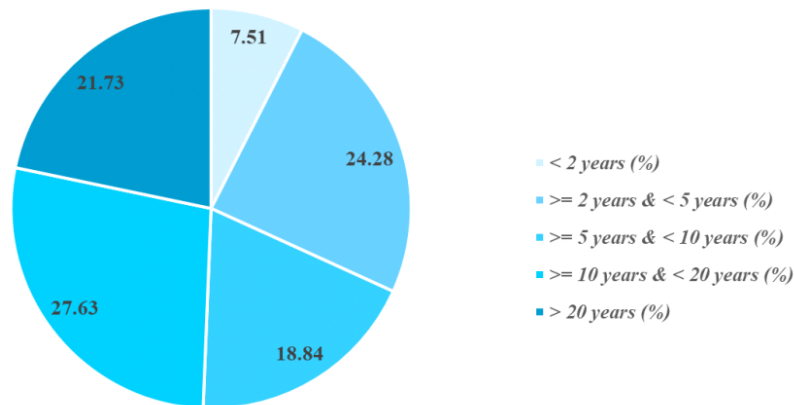| Family Size	Frequency	Percent	Cumulative Percent
1	73	8.50	8.50
2	152	17.69	26.19
3	150	17.46	43.66
4	234	27.24	70.90
5	157	18.28	89.17
6 and more	93	10.83	100.00
Total	859	100.00	

Figure 2. Length of residence in the city/municipality

Around 58% of the sample population lived in family-owned houses, 33% lived in rented houses, and 9% reported other settings. Most of the respondents (≈ 60%) lived in either detached or semidetached houses, and about 20% resided in apartment buildings of 9 storey or more (Fig. 3).
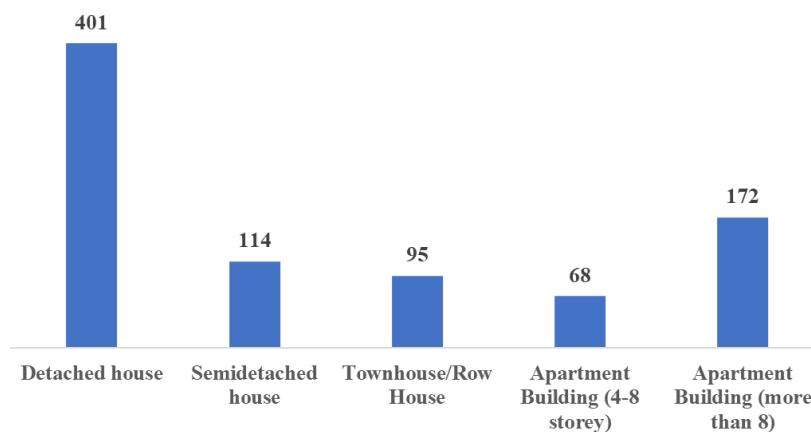
Figure 3. House types reported by the respondents

Finally, the respondents' answers indicated that over 80% had university or college education (Table 2).

Results and Discussion

In this section, we provide the main results of our analysis and discuss our key findings. We start with the impact of the December 2013 Ice Storm as reported by the respondents, which is followed by a discussion regarding the extent to which the respondents were prepared for the event. Then, lessons learned, and preparedness actions taken for future ice storms will be provided. Finally, we discuss several factors that are related to households' preparedness before and after the 2013 Ice Storm.

Table 2. Highest level of education reported by the respondents

Level of Education	Frequency	Percent	Cumulative Percent
Some School	16	1.85	1.85
High School	124	14.34	16.18
Some College	64	7.40	23.58
College	88	10.17	33.76
Some University	173	20.00	53.76
Bachelor's degree	286	33.06	86.82
Master's degree	100	11.56	98.38
PhD	14	1.62	100.00
Total	865	100.00	

Impacts of the December 2013 Ice Storm

The majority of the respondents (≈ 58%) indicated that the 2013 Ice Storm created some form of inconvenience for their families (Fig. 4).

Figure 4. Level of inconvenience caused by the 2013 Ice Storm
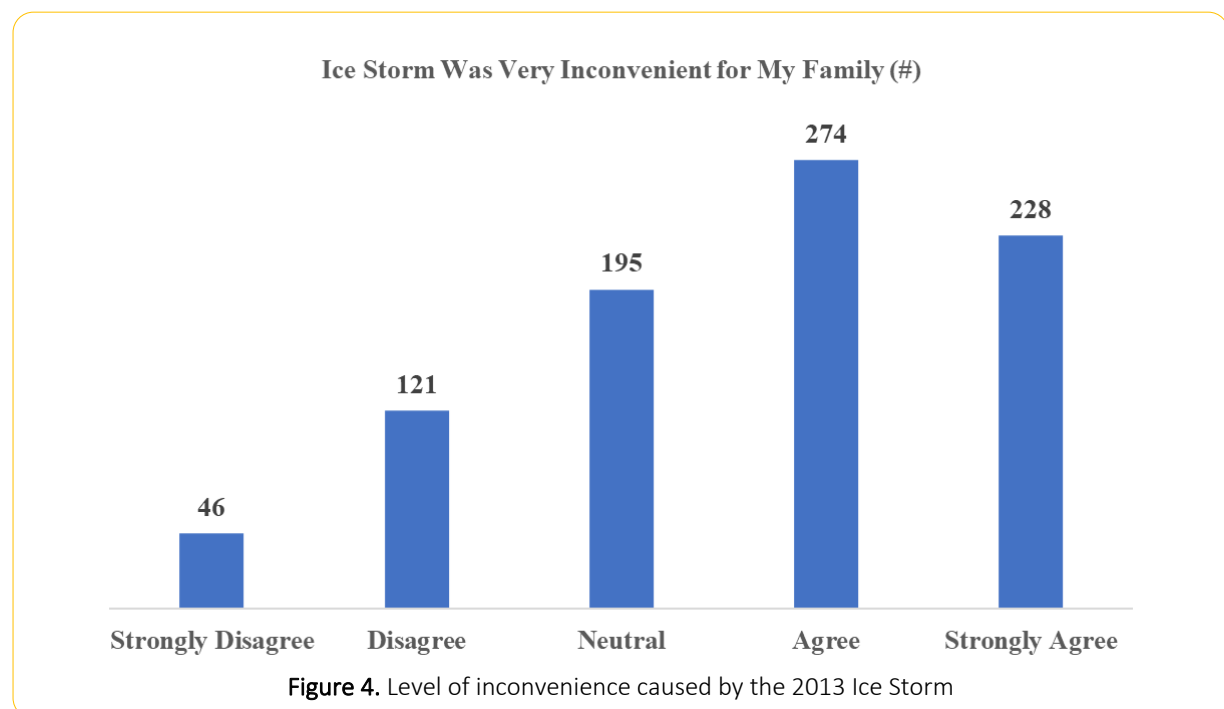
Households experienced various disruptions during the ice storm. The most important disruption was power outage, which impacted more than half of the sample households (≈ 60%), some of whom spent several days without power (Fig. 5).

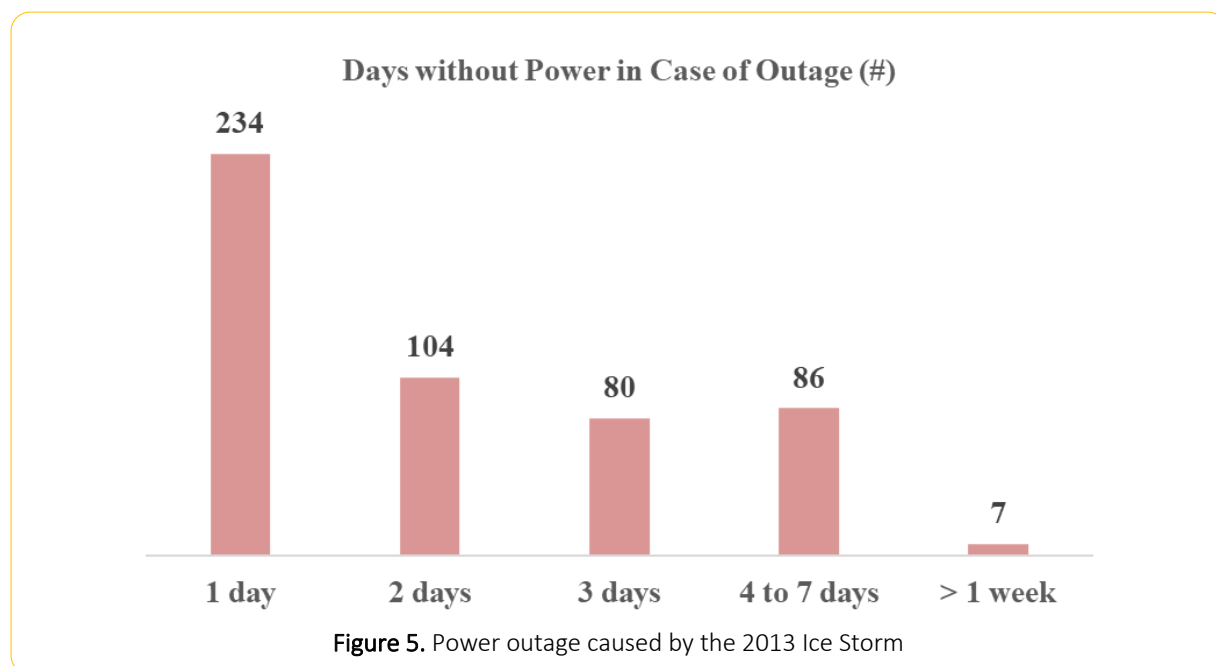**Figure 5.** Power outage caused by the 2013 Ice Storm

Table 3. Types of disruptions experienced by respondents during the December 2013 Ice Storm

Type of Disruption	Total	Yes (%)	No (%)	Min	Max	Length of Disruption				
						1 day (%)	2 days (%)	3 days (%)	4 to 7 days (%)	> 1 week (%)
Power outage	865	59.5	40.5	1	20	27.1	12.0	9.3	10.0	0.8
Water outage	865	14.1	85.9	1	7	6.1	3.8	2.8	2.0	0.0
Telephone outage	865	25.8	74.2	1	15	11.6	5.1	3.9	4.6	0.5
Natural gas outage	865	9.7	90.3	1	7	4.4	3.1	1.6	1.4	0.0
Transportation disruptions (land, air)	865	39.5	60.5							
Physical harm or injury	859	4.2	95.8							
Food shortage at home	863	12.5	87.5							
Health issues due to low home temperature	864	11.0	89.0							
Income loss	865	11.7	88.3							
Property damage (car, house)	864	11.2	88.8							
Property damage (trees)	865	35.5	64.5							
Banking disruptions	864	9.1	90.9							
Staying with friends/relatives	864	16.9	83.1	1	14	5.7	5.5	3.0	3.0	0.5
Staying in hotel/motel	864	3.4	96.6	1	7	1.5	1.6	0.6	0.4	0.0
Staying in community centre	865	1.3	98.7	2	2	0.0	1.3	0.0	0.0	0.0
Events/trip cancelation	864	13.1	86.9							
Hosting friends/relatives	865	15.7	84.3	1	8	7.0	4.2	2.3	1.6	0.1

Other notable disruptions were transportation disruption, property damage (trees), and telephone outage, which affected around 40%, 35%, and 26% of the sample households, respectively. Respondents also reported the following: leaving home and staying with friends/relatives (≈ 17%), hosting friends/relatives (≈ 16%), water outage (≈ 14%), events or trip cancelation (≈ 13%), food shortage at home (≈ 13%), income loss (≈ 12%), property damage

to car or house (≈ 11%), health issues due to low home temperature (≈ 11%), natural gas outage (≈ 10%), and banking disruptions (≈ 9%). The remaining disruptions, i.e. physical harm/injury, staying in hotels, and staying in community centre, each affected less than 5% of the sample population. The length of disruptions varied from 1 day to a maximum of 20 days for power outage, 1 to 15 days for telephone outage, and 1 to 7 days for water and natural gas outages. However, more than 80% of the outages restored within 3 days, and less than 2% of the power and telephone disruptions lasted more than a week. Further details are provided in Table 3.

Preparedness for the 2013 Ice Storm
We asked the respondents' opinions about various aspects of the 2013 Ice Storm and the extent to which they were prepared for it (Fig. 6). The respondents were divided in terms of reporting whether they received adequate advance warnings – 36% disagreed, 24% answered neutral, and 40% agreed that they received adequate warnings (6A). This could be due to the timing of the event; the ice storm hit Ontario only days before Christmas; hence, most people were probably busy with preparations and shopping for last-minute gifts. A significant portion of the respondents (≈ 45%) were not prepared for the December 2013 Ice Storm (6B), 29% were undecided, and only 26% were prepared. Some reasons could be derived from the survey results. For example, about 60% of the respondents indicated that the 2013 Ice Storm was the first ice storm that they experienced (6C). Further, around 60% of the respondents did not have a family emergency plan (6D) and 69% of the respondents did not have a 72-hour emergency kit (6E) at the time the ice storm hit. Despite the lack of a family emergency plan, a 72-hour emergency kit, and experience in dealing with ice storms, most of the respondents were still able to manage the effects of the ice storm since almost half of the respondents had enough food to consume during the ice storm (6F).

Our survey indicated that the role of local news sources and media outlets in disseminating information to mass audiences was effective as 65% of the respondents were satisfied with the media in their ability for providing adequate and up-to-date reports on the ice storm (6G). Finally, only 39% were satisfied with the hydro companies' response and recovery efforts during the ice storm, 39% were neutral, and 23% were dissatisfied (6H).

Lessons learned and preparedness actions taken for future ice storms
In a series of questions, we asked respondents about the lessons learned and preparedness measures taken after the 2013 Ice Storm. As Fig. 7 indicates, almost 70% of the respondents reported that they learned a lot about ice storms and their impacts because of the December 2013 Ice Storm (7A). Moreover, around 47% of the respondents said that their families are better prepared for the next ice storm compared to the 2013 Ice Storm (7B). As alluded to earlier, most of the households did not have family emergency plans before the ice storm; however, learning from the event, a significant portion of them (≈ 41%) indicated that they have improved their family emergency plans (7C). While 43% of the respondents have not purchased essential items nor stored food and water in case of an ice storm emergency (7D), 46% stated that they intend to do so (7E). Also, 72% of those surveyed disagreed that they did not have a power generator before but decided to purchase one after the 2013 Ice Storm (7F). This could be due to several reasons. First, some of the respondents may already possess power generators in case of a blackout. Second, some of the respondents may have limited funds and may feel that their money would be better spent on more important things than a power generator. Third, even with enough funds to spend on a power generator, some people may not see it as a crucial item in terms of surviving a disaster.
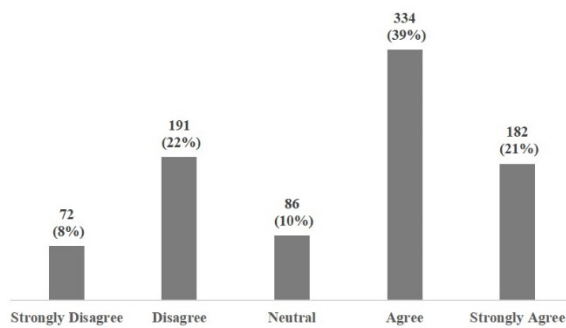
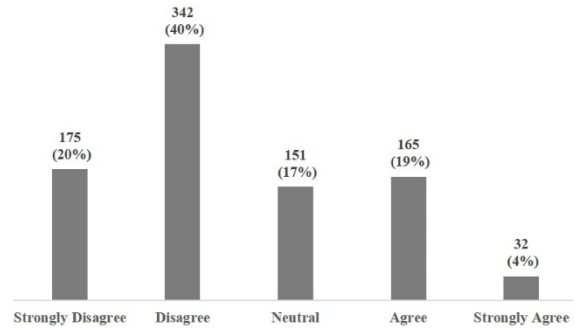**6A.** We received adequate advance warnings about the ice storm before it reached our city/municipality.
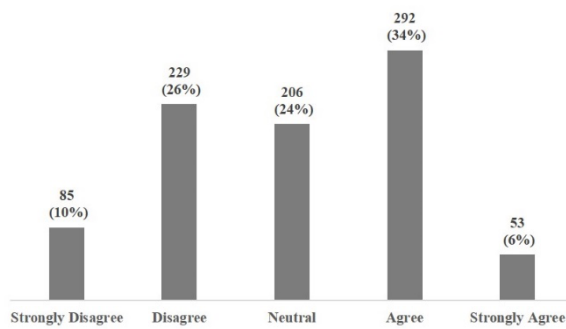
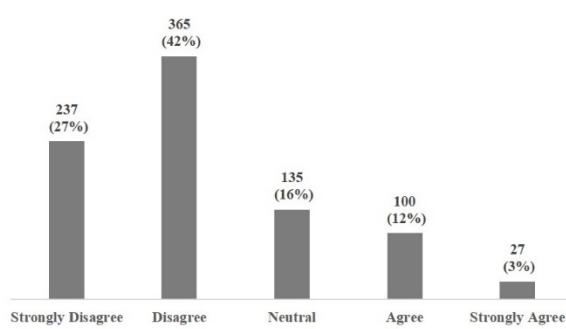**6B.** My family was prepared for the 2013 Ice Storm.
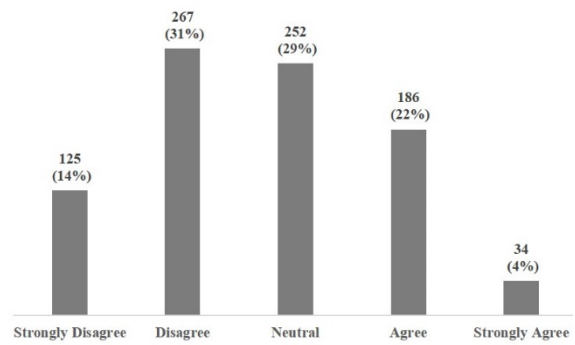
6C. It was the first time that we were observing an ice storm.
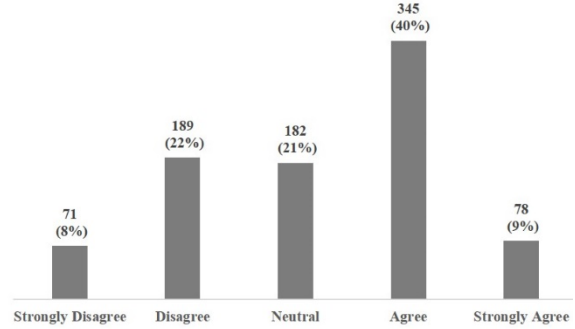
6D. My family and I had a family emergency plan if the effects of the ice storm became unbearable.
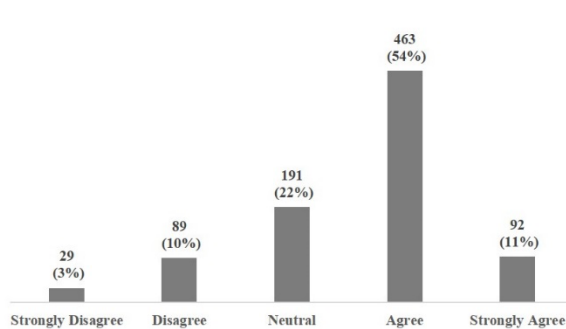
6E We had a 72 hours emergency kit at home and it was very useful.

6F. My family had stored food items at home and used them during the ice storm.

6G. Local news sources and media outlets provided adequate, up-to-date reports on the ice storm.

6H. Hydro companies' response and recovery efforts during the ice storm was satisfactory.
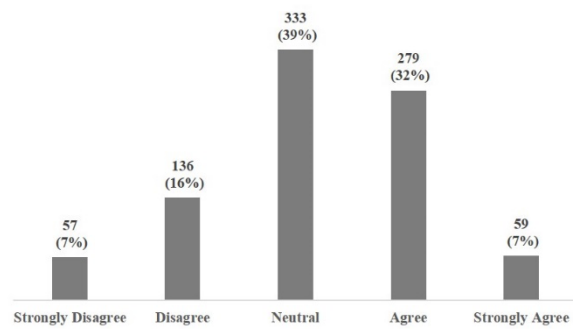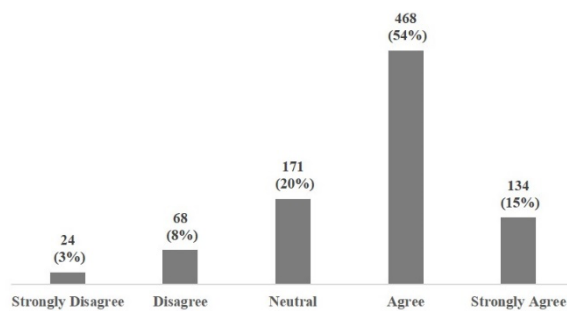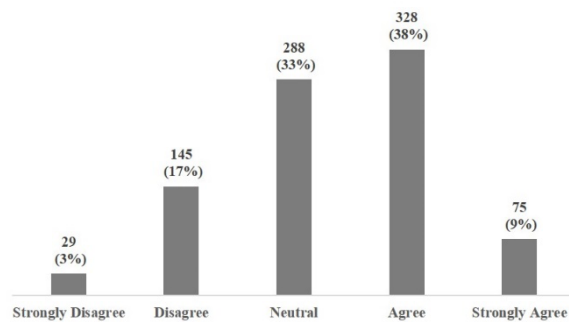
Figure 6. The 2013 Ice Storm and household preparedness reported by the respondents
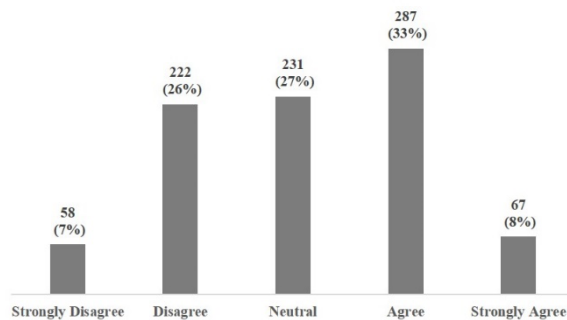
7A. We learned a lot about the ice storm and its impact because of the December 2013 Ice Storm.


7B. Compared to the previous ice storm, my family and I are much better prepared for the next ice storm.


7C. Learning from the December 2013 Ice Storm, we have improved our family emergency plan (how to communicate with each other, where to go in case of emergency, etc.).

7D. Learning from the December 2013 Ice Storm, we have purchased essential items (such as emergency kits) and have stored water and food in case of ice storm emergency.
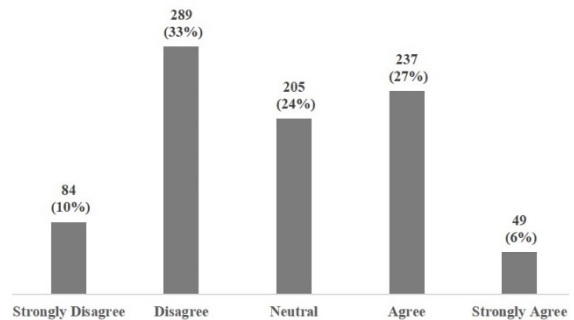
7E. We intend to buy the necessary items to cope with a potential ice storm.
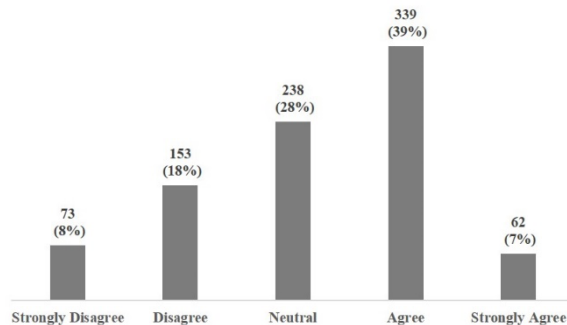
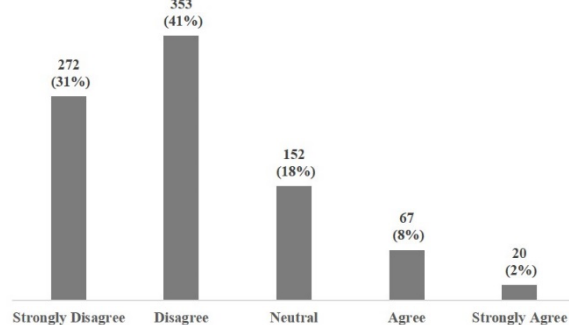**7F.** We did not have a power generator before, but we decided to purchase one.

Figure 7. The 2013 Ice Storm and preparedness for future ice storms

7G. We pay attention to emergency preparedness information provided by the media.
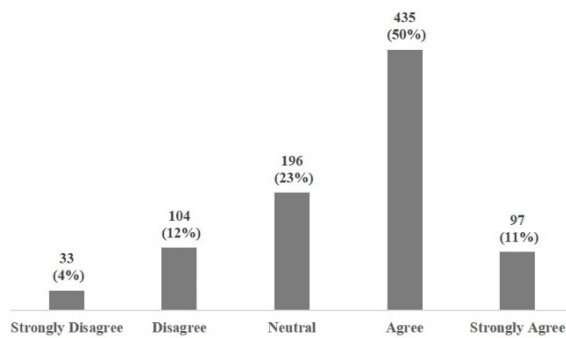
7H. My family and I receive regular public education materials regarding emergency situations including ice storm from our municipality.
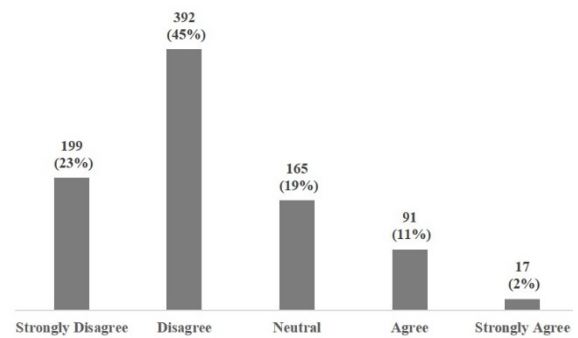
7I. My family and I would be able to attend public emergency preparedness training program if offered.

7J. It is the city/municipality's responsibility to prepare for the emergencies like ice storm.
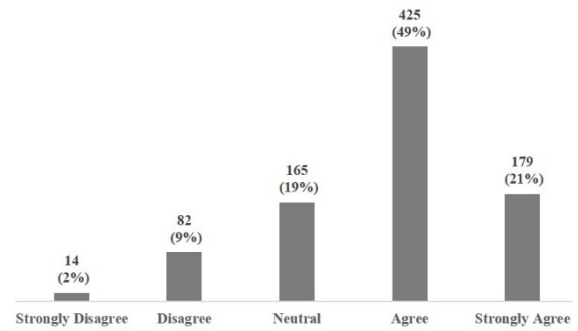
7K. The city/municipality should invest large amounts of money into reducing the impacts of future ice storms.
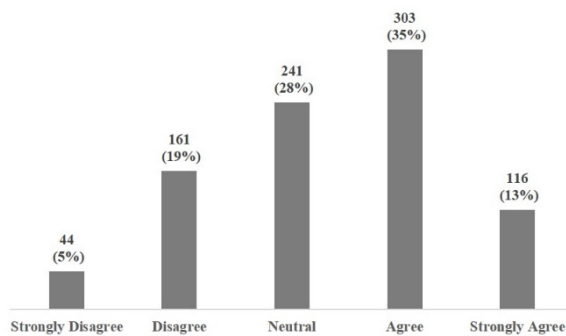
7L. Generally speaking, our city/community is well prepared for future ice storm.

Figure 7 (cont'd). The 2013 Ice Storm and preparedness for future ice storms

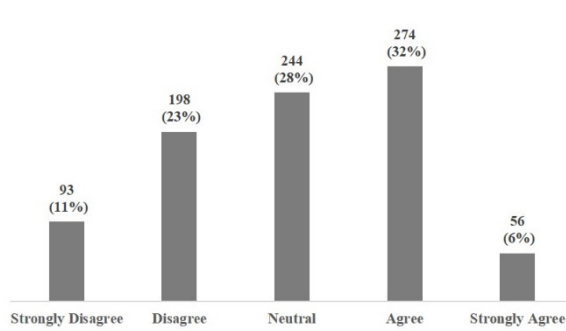As discussed earlier, most of the respondents described the information distributed by local news sources and media outlets as adequate and up-to-date during the 2013 Ice Storm. Data collected from the survey shows that 61% of the respondents pay attention to emergency preparedness information provided by the media (**7G**). However, 68% of the respondents said that they do not receive regular public educ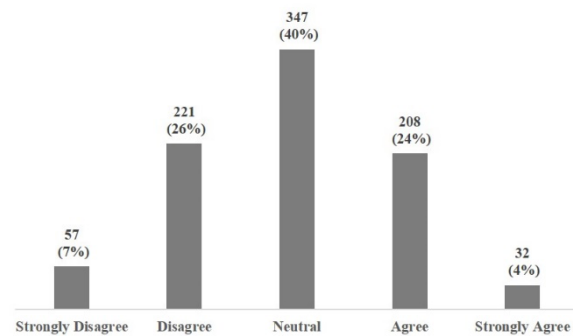ation materials regarding emergencies from their municipalities (**7H**). Besides, the respondents seem to be divided in terms of attending public emergency preparedness training programs – 38% are willing to attend, 28% are neutral about the subject, and 34% said they would not be able to attend (**7I**).

Most of the respondents (≈ 70%) believe that the city/municipality is the main responsible entity for preparing for emergencies such as ice storms (**7J**), and a significant portion of them (≈ 48%) think that the city/municipality should invest large amounts of money to reduce the impacts of future ice storms (**7K**). Also, a divided pattern is observed in terms of the respondents' opinions regarding the extent to which their cities/municipalities are actually prepared for future ice storms (**7L**). Finally, the survey results (not shown here) reveal the following: 34% think that the focus should be directed toward other hazards in their city/community that are more important than the ice storm; 38% indicate that there are other more important family and life issues that they are dealing with; and, 25% believe that the probability of another ice storm in near future is very low.

Factors affecting households' preparedness
To conduct a few tests for independence or association, we use simple bivariate Chi-square tests. Further, Pearson or Spearman correlations are reported from SPSS. It is important to note that cities where the respondents live (Fig. 1) are numerically coded into seven categories. Also, the number of years lived in the current city is represented by only two categories: less than 10 years and greater than or equal to 10 years. Results of Chi-square tests show that a significant association (at the 0.05 significance level) exists between the preparedness of families and several sociodemographic characteristics (Table 4).

Table 4. Association of sociodemographic characteristics and previous preparedness of families

	Variable name	Chi-Square value	df	Asymptotic Significance (2-sided)	Pearson/ Spearman Correlation
Sociodemographic Variables	Where do you live	38.959	24	**0.028**	0.124
	How long you have lived in your current city/community	12.489	4	**0.014**	0.111
	Including yourself how many people live in your family (size)	48.238	40	0.174	0.041
	< 12 years old	41.852	20	**0.003**	-0.112
	> 65 years old	7.713	8	0.462	0.010
	Disable people in the family	8.485	8	0.388	0.044
	Gender	2.193	4	0.700	-0.033
	Level of education	44.952	28	**0.022**	-0.007
	Ownership	24.034	8	**0.002**	-0.102
	House type	19.266	20	0.505	-0.084
	Do you have pets	14.149	4	**0.007**	-0.108

As Table 4 depicts, the preparedness of families against the 2013 Ice Storm in the GTA was associated with sociodemographic characteristics such as respondents' current city/community and length of stay in that location, level of education, house ownership, and having or not having children and pets. For example, families in Toronto reported lower than expected and families in Vaughan reported higher than expected levels of preparedness. Further, households in which the occupants had lived 10 years or more reported higher preparedness levels. Also,

higher preparedness was reported by households with no children under 12 years old. Although the level of education was found to be related to preparedness, this relationship was not monotonic; in general, college graduates reported the highest, and those who didn't graduate high school reported the lowest preparedness levels. Finally, homeowners reported higher preparedness compared to renters, and those who had pets were more prepared for the ice storm.

Learning from the December 2013 Ice Storm, what factors might have been influential in improving the preparedness of families for similar situations in the future? To this end, we first calculate a "next preparedness index" by averaging (and then rounding to the nearest integer) those variables that are assumed to collectively represent preparedness for future events: (1) *"Learning from the December 2013 Ice Storm, we have improved our family emergency plan (how to communicate with each other, where to go in case of emergency, etc.)"*; (2) *"Learning from the December 2013 ice storm, we have purchased essential items (such as emergency kits) and have stored water and food in case of ice storm emergency"*; (3) *"We did not have a power generator before, but we decided to purchase one"*; (4) *"We intend to buy the necessary items to cope with a potential ice storm"*; (5) *"My family and I receive regular public education materials regarding emergency situations including ice storm from our municipality"*; (6) *"My family and I would be able to attend public emergency preparedness training program if offered"*; (7) *"We pay attention to emergency preparedness information provided by the media"*; and, (8) *"Compared to the previous ice storm, my family and I are much better prepared for the next ice storm"*. Then, we examine how sociodemographic characteristics as well as 2013 Ice Storm disruptions are related to next preparedness. For the former, the only variable that seems to be significantly related to next preparedness is home ownership: homeowners tend to be more prepared for the next ice storm compared to renters (numerical results not shown). The latter is discussed in the next paragraph.

Table 5. Chi-square test results for the relationship between next preparedness and 2013 Ice Storm disruptions

	Variable name	Chi-Square value	df	Asymptotic Significance (2-sided)	Pearson/ Spearman Correlation
	Power outage	11.699	4	**0.020**	-0.015
	Water Outage	5.715	4	0.221	-0.067
	Phone outage	5.596	4	0.231	-0.055
	Natural Gas	8.618	4	0.071	-0.041
	Transportation Disruption	2.215	4	0.696	0.003
	Physical injury	6.179	4	0.186	0.010
	Food shortage	2.770	4	0.597	-0.040
Disruption Variables	Health issue due to low home temperature	1.083	4	0.897	-0.004
	Income loss	6.782	4	0.148	-0.079
	Property damage	1.100	4	**0.014**	-0.032
	Staying with friends	9.171	4	0.057	-0.098
	Staying in hotel	21.844	8	**0.005**	-0.097
	Staying in community centre	1.985	4	0.738	-0.040
	Event/Trip cancelation	6.382	4	0.172	-0.061
	Hosting friends	2.654	4	0.617	0.014

We conduct cross-tabulation analysis and Chi-square tests (at the 0.05 significance level) to find out what kinds of disruption experiences are associated with the next preparedness. The results are presented in Table 5. As the table shows, a significant association was found between next preparedness and a number of disaster-related

experiences. Those who experienced power outage, property damage, or staying in hotel, reported more than expected levels of next preparedness.

Conclusions

The heavy fall of freezing rain along the northern coast of Lake Ontario during the cold winter of 2013 led to one of the worst ice storms to hit Southern Ontario and the GTA (Canada). The December 2013 Ice Storm was associated with notable consequences, including several days of power outage, which affected around 2.5 million individuals across Southern Ontario. The ice storm also caused injuries, damaged trees, disrupted transportation, and interrupted business activities. While the ice storm caused a lot of disruption and inconvenience, lessons can be learned from this event to improve disaster preparedness for similar events in the future. The main objective of this study is to understand whether this major event has enhanced people's awareness and preparedness for this kind of emergency.

While the existing literature includes theoretical frameworks and case studies on disaster preparedness (and how it is influenced by various factors pertaining to community engagement, sociodemographic factors, public awareness, and disaster experience) in several different settings, we made an effort to conduct empirical research focused on the December 2013 Ice Storm in the GTA, in order to better understand individual/household disaster preparedness and the associated factors. For data collection, we designed a questionnaire, which was completed by 865 individuals from various parts of the GTA (> 95%) and several surrounding towns (< 5%). The questionnaire had three sections: Section 1 contained questions regarding the impacts experienced and the preparedness levels reported by the respondents during the 2013 Ice Storm; Section 2 included questions about lessons learned from the 2013 Ice Storm and preparedness actions taken for future ice storms; and, Section 3 consisted of questions to collect sociodemographic data about the respondents.

We list a number of limitations that need to be recognised in this research. First, this study relied on self-reported preparedness assessment which may be different from objective assessment. Second, our analysis did not account for variation to memory after the event (Lambrou, 2014) and did not control for hindsight bias (Guilbault et al., 2004; Roese & Vohs, 2012). Third, the questionnaires were distributed using convenience sampling and therefore the respondents may not perfectly represent the whole population.

We summarize the key findings of our study as follows. As reported by the survey's participants, several disruptions were experienced in the GTA, the most common of which was power outage, followed by transportation disruption, property damage (trees), and telephone outage. A significant portion of the households were not prepared for the December 2013 Ice Storm, and the majority indicated that the ice storm was inconvenient for them. Further, while most participants reported that they would pay attention to emergency preparedness information provided by the media, they were divided in reporting whether they received adequate advance warnings about the ice storm before the event.

Not surprisingly, the greater part of the respondents reported that they learned a lot about ice storms and their impacts because of the December 2013 Ice Storm. Further, excluding those who were neutral on the subject, the respondents mostly regarded their families as better prepared for the next ice storm compared to the 2013 Ice Storm. While most of the respondents said they would pay attention to emergency preparedness information provided by the media, they seemed divided in terms of willingness to attend potential public preparedness training programs. Also, a significant majority believe that it is the city/municipality's responsibility to prepare for emergencies like ice storms, and about half of the participants think that the city/municipality should invest heavily in risk reduction from potential future ice storms. These results show that prior disaster experience may not actually lead to enhanced preparedness in every case. Despite public education and experience of a disaster, people may exhibit a lukewarm commitment to preparation while believing they are better prepared; this is in agreement with the Community Engagement Theory discussed before (Paton, 2019). In general, prior experience

can be considered as one of the many factors potentially influencing disaster preparedness; for example, it could be one of the variables along a causal chain, preceded by hazard proximity and followed by risk perception and consequent hazard adjustment adoption, according to the Protective Action Decision Model (Lindell & Perry, 2012).

We also analyzed a few relationships between variables: City/community, length of stay, level of education, house ownership, having children, and having pets were found to have significant associations with the previous ice storm preparedness. Also, power outage, property damage, and staying in hotel were each significantly associated with the next ice storm preparedness.

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