The Influence of Previous Disaster Experience and Sociodemographics on Protective Behaviors during Two Successive Tornado Events

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ABSTRACT

The role of previous disaster experience as a motivating factor for protective action during high-risk events is still a matter of considerable discussion and inconsistent findings in the hazards literature. In this paper, two events that occurred in August 2011 in Goderich, Ontario, Canada, are examined: an F3 tornado that impacted the community on 21 August 2011 and a tornado warning that was posted for the region 3 days later on 24 August 2011. This case study provided the opportunity to examine the roles of previous disaster experience and sociodemographics on the decision-making process during two successive potentially tornadic events. The results of this research are based on close-ended questionnaires completed by individuals who experienced both storms or who experienced only the subsequent storm on 24 August 2011 ($n = 177$). Physical cues were found to be the primary motivator during the 21 August 2011 tornado, while the tornado warning was the primary motivator during the subsequent storm. Additionally, there was an increase in the percentage of individuals who took protective action on 24 August 2011 regardless of the respondents' presence or absence during the 21 August 2011 tornado. Finally, none of the tested sociodemographic variables was found to be statistically significant for the 21 August 2011 tornado, while only gender (female) was found to be positively correlated with protective behaviors on 24 August 2011. These findings suggest that previous disaster experience (either direct or indirect) and sociodemographics intersect in a variety of complex ways.

1. Introduction

Tornadoes represent a significant risk to residents of both the United States and Canada. On average, the United States experiences approximately 1300 tornadoes each year, resulting in an annual average of 70 deaths and 1500 nonfatal injuries (NOAA 2013). The atmospheric conditions necessary for the development of these destructive storms also occur in Canada, with an average of 80–100 confirmed or probable tornadoes reported in the country each year (Environment Canada 2012). These storms are among the most destructive atmospheric phenomena on Earth, and are "from a meteorological and climatological perspective, one of nature's most challenging perils" (Etkin et al. 2001, p. 915).

A substantial portion of the literature pertaining to the societal aspects of these intense storms focuses on the various factors that influence warning response. These factors may be either external to the individual or individual controlled. Examples of externally controlled factors include time of tornado occurrence, average warning lead time, the dissemination of official watches and warnings, access to suitable shelters, and environmental cues (e.g., Sorensen 2000; Grazulis 2001; Simmons and Sutter 2008; Hammer and Schmidlin 2002; Sherman-Morris 2005, 2010; Ashley et al. 2008; Schmidlin et al. 2009; Lindell and Perry 2012; NOAA 2011). Individual-level factors that influence warning response include previous disaster experience (including past experience with false alarms), risk perception, and sociodemographics (e.g., Simmons and Sutter 2009; Kasperson et al. 1988; Sorensen 2000; Comstock and Mallonee 2005; Donner 2007). In particular, the influence of previous disaster experience and sociodemographics on decision-making remains a topic of considerable discussion in the hazards literature, owing to the variations in their apparent influence from study to study.

Research on the role of previous disaster experience during subsequent events includes studies across a spectrum of hazards, such as hurricanes (e.g., Baker 1979; Cross 1990; Dillon et al. 2011; Sharma and Patt 2012),

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volcanic eruptions (e.g., Paton et al. 2008; Paton et al. 2000), and tornadoes (e.g., Comstock and Mallonee 2005; Schmidlin et al. 2009). However, the findings of this research are divided. Within the tornado literature specifically, few studies exist that attempt to isolate and examine the role of previous disaster experience during subsequent events; fewer still attempt to do so for a single population for two successive events—Comstock and Mallonee (2005) is a notable exception. However, even within this narrowly defined subfield, the insights that emerge do not provide a coherent picture of the role of previous disaster experience in successive hazardous events. As with the broader hazards literature, results are often inconsistent between studies, with some research finding a positive correlation between previous disaster experience and protective action (e.g., Comstock and Mallonee 2005; Mileti and Sorensen 1987; Murphy et al. 2005), while others show no clear relationship (e.g., Donner 2007; de Man and Simpson-Housley 1987; Liu et al. 1996; Balluz et al. 2000; Schmidlin et al. 2009).

One potential explanation for this inconsistency may be that most studies lack a common conceptualization of previous disaster experience. Previous disaster experience encompasses a broad spectrum of incidents that includes both direct and indirect experiences, the frequency and severity of past occurrences, a variety of hazard types, and experience with false alarms (e.g., Simmons and Sutter 2009; Sharma and Patt 2012). In terms of direct *versus* indirect hazard experience, previous research found that direct experience with hazards has a greater effect on risk perception and/or protective behaviors than indirect experience (e.g., Paton et al. 2000; Blanchard-Boehm and Cook 2004; Anderson-Berry 2003). For example, Paton et al. (2000) found that vicarious experience with volcanic hazard did not improve either risk perception or protective behaviors among respondents. Blanchard-Boehm and Cook (2004) found that "intense" direct experience with the 31 May 1985 Edmonton, Alberta, Canada, tornado positively influenced preparedness for future hazards, while Anderson-Berry (2003) similarly attributed improvements in tropical cyclone warning response to direct experience with a damaging tropical cyclone.

In contrast, the Social Amplification of Risk Framework (SARF) suggests that indirect disaster experience may also influence risk perception (and subsequently, warning response) if heightened sensitivity is present. According to this conceptual framework, direct experience with a dramatic hazard amplifies risk perception during subsequent events (Kasperson et al. 1988). In lieu of direct personal experience, indirect experience may also amplify risk perception if information flow among individuals, and between individuals and the media is of high volume and/or dramatization (Kasperson et al. 1988). Thus, both direct and indirect previous disaster experience may influence warning response during successive events depending on various contextual factors.

As with previous disaster experience, the influence of personal attributes on decision making during high-risk, short-notice disasters also varies across studies. The key demographics that are often cited as highly correlated with protective action are gender, age, education, ethnicity, and income (e.g., Mileti and Sorensen 1990; Sorensen 2000). Other common demographic variables include employment category, residential mobility, marital status, and number of dependents (Sorensen 2000). In terms of gender in particular, many studies have found that females are more likely to take protective action during high-risk events (e.g., Sherman-Morris 2005, 2010; de Man and Simpson Housley 1987; Murphy et al. 2005). However, occasionally a study will show the opposite (e.g., Schmidlin et al. 2009), or will provide mixed or inconclusive results (e.g., Nagele and Trainor 2012).

Given society's increasing exposure to high-consequence storm events, there is a need for an improved understanding of the factors that influence individuals' protective actions. Tornadic activity in August 2011 in the rural community of Goderich, Ontario, Canada, provides an opportunity to explore the ways in which both previous disaster experience and sociodemographics influenced protective-action decision making. The event sequence investigated in this research paper includes an F3[1] tornado on 21 August 2011 and a tornado-warned storm that affected the region 3 days later on 24 August 2011. This case study is particularly notable as Goderich had never previously experienced a tornadic event despite being located in a geographic region at risk for these damaging storms. The overall purpose of this research is to better understand the factors that influence individuals' behaviors, focusing in particular on previous disaster experience and demographics. The specific research questions include the following:

1) What factor(s) motivated protective actions during the 21 August 2011 tornado and during the subsequent storm on 24 August 2011? In particular, what role did previous disaster experience have as a motivating factor on 24 August 2011?
2) What sociodemographic variables (if any) were positively correlated with protective-action decision making?

[1] Environment Canada adopted the enhanced Fujita scale on 1 Apr 2013.

FIG. 1. Map of Goderich, Ontario. (Courtesy of R. Harris.)

2. Study area and event background

a. Tornadoes in southern Ontario

Approximately 80–100 tornadoes occur in Canada each year, resulting in an annual average of two deaths, 20 injuries, and tens of millions of Canadian dollars (CAD) in damages (Environment Canada 2012; Cao and Cai 2011, 2008). Although tornadoes can occur any time of year given the necessary atmospheric conditions, peak tornado season in Canada is June–August (Environment Canada 2012). The Canadian region at the highest risk of tornadoes is the southwestern portion of the province of Ontario (Etkin et al. 2001; Conrad 2009), which is located at the northernmost extent of America's ''Tornado Alley'' and cradled by Lakes Huron, Erie, and Ontario of the Great Lakes system (Etkin et al. 2001). Based on assessments of tornado frequency and intensity, an F3 tornado affects southern Ontario every 5 yr, on average (Sills et al. 2004); less intense tornadoes typically affect southern Ontario every year (Banik et al. 2007). Given that southern Ontario accounts for approximately 35% of Canada's total population (McGillivray 2010), the tornado hazard in this region poses a significant risk to millions of Canadians.

b. Goderich, Ontario

Goderich is a small town with a population of approximately 7500 residents located on the eastern shore of Lake Huron in the county of Huron, Ontario (Fig. 1). The surrounding region is primarily agricultural, and the town spans a total land area of 7.91 km^2 (Statistics Canada 2012). The downtown core of Goderich is an octagonal traffic circle, which houses a number of businesses, including four banking institutions, two art galleries, a historic hotel, and numerous specialty stores. The Huron County Courthouse, which provides family, criminal, and court services for the region, is located at the center of the square. As a regional service center, Goderich provides retail, municipal, and economic functions for the surrounding area.

Because of its position on Lake Huron, Goderich experiences a variety of weather disturbances throughout the year. In the winter months, snow squall and blizzard warnings are common. During the summer months, severe thunderstorms often develop over Lake Huron and blow ashore into Huron and Perth Counties. It is not unusual for these thunderstorms to include high winds, heavy rain, and sizable hail. Although Goderich experienced a significant wind event in 1996, there was no

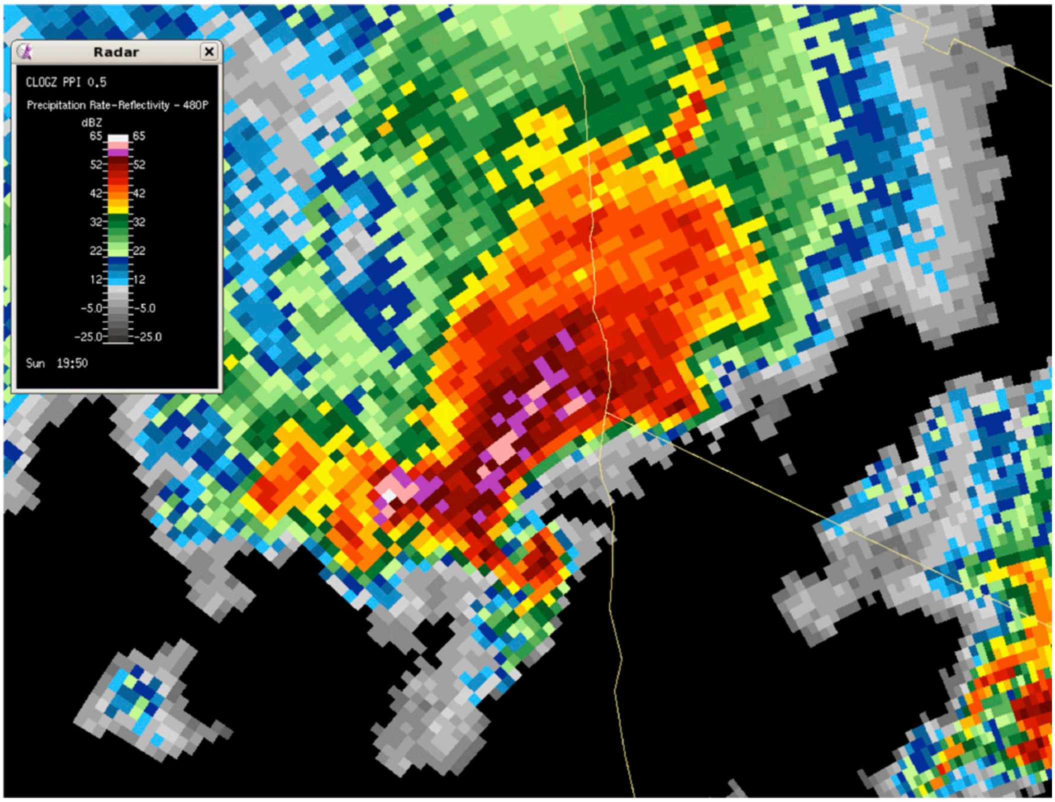

FIG. 2. Exeter 0.5° radar reflectivity (1550 EDT) of the tornado-warned storm as it approached Goderich, Ontario, on 21 Aug 2011. Note the characteristic hook echo in the bottom middle of the figure. (Sills and Ashton 2012, used with permission.)

history of confirmed tornadic activity in the area prior to August 2011. Other than the Goderich tornado, the next most recent major tornado in the area was an F3 tornado that occurred in Violet Hill, Ontario (over 150 km to the northeast), on 20 April 1996. Although several communities in southern Ontario have outdoor warning sirens, Goderich is not among them.

c. 21 August 2011 Goderich, Ontario, tornado

Throughout the early afternoon of 21 August 2011, Goderich experienced several periods of unsettled weather, with rain, hail, and wind occurring shortly after noon. At 1402 EDT 21 August 2011, a severe thunderstorm watch was posted for the Huron and Perth Counties by Environment Canada. Although there was no separate tornado watch posted at this time, the possibility of a tornado was mentioned in the text of the severe thunderstorm watch. Approximately 1 h later, an isolated supercell thunderstorm moved over Lake Huron and intensified as it approached the town of Goderich. At this time, Doppler radar showed an organized severe thunderstorm with a characteristic "hook echo" (Fig. 2), which is indicative of intense rotation associated with tornadoes. At 1548 EDT 21 August 2011, Environment Canada issued a tornado warning for Goderich, Ontario, as well as for most of the surrounding area and southern Lake Huron (Environment Canada 2011b).

Approximately 10 min after the tornado warning was issued by Environment Canada, the storm came ashore directly into the downtown core of Goderich. The storm then traveled 20 km in a southeasterly direction, leaving behind a damage path between 200 m and 1.5 km wide (Environment Canada 2011a). As a result of the tornado, one individual died and at least 39 others were injured, five of whom required urgent medical assistance. Based on a damage assessment survey conducted the following day, Environment Canada classified the tornado as an F3, with maximum wind speeds of 280 km h^{-1} (174 mi h^{-1}).

The 21 August Goderich tornado was the strongest tornado to affect southern Ontario in 15 yr. The storm damage in Goderich was extensive, particularly in the downtown core around the courthouse square. Because of damaged lines in the area, natural gas service was cut off to about 3300 customers around 2200 EDT that evening. Many buildings received serious structural damage, including residential and commercial buildings, the Sifto Salt Mine, and the Goderich Courthouse. A number of buildings were destroyed by the tornado, while others were damaged beyond repair and were subsequently approved for demolition. As of 21 September 2011, the Goderich tornado has cost at least $75 million CAD in insured damages (IBC 2012).

d. 24 August severe storm system

Three days after the Goderich tornado, atmospheric conditions were again primed for an outbreak of severe weather in southern Ontario. Early in the day on 24 August 2011, both Environment Canada and the Storm Prediction Center (SPC) recognized that several atmospheric conditions necessary for the development of severe thunderstorms would converge over southern Ontario and the U.S. upper Midwest. By early morning, Environment Canada had issued a tornado watch for large portions of southern Ontario, including the town of Goderich. The text of the watch indicated that severe thunderstorms with heavy rains, damaging winds, large hail, and destructive tornadoes were possible. Throughout the day, Environment Canada extended the tornado watch to encompass most of southern Ontario. By late afternoon, numerous severe thunderstorm cells began to develop and track across southern Ontario. In response, Environment Canada upgraded the tornado watch to a tornado warning for the Goderich region at 1830 EDT 24 August 2011. Although no tornadoes were reported in Goderich, this storm system did cause heavy rainfall and strong winds in southwestern Ontario. The storm system was also responsible for three confirmed tornadoes in other areas in southern Ontario that are located within 125 km of Goderich: an F1 tornado touched down in Nairn and Cambridge, and an F0 tornado occurred in Neustadt (Environment Canada 2011a).

3. Methods

Primary data were collected in two phases. First, 35 semistructured interviews were conducted with Goderich-area residents to examine their experiences, beliefs, perceptions, and behaviors during the 21 August 2011 tornado and the subsequent severe storm event. Many questions that appeared in the interview script were drawn from previous studies that examined tornado perception and response in the United States (e.g., Donner 2007; Sherman-Morris 2010; Comstock and Mallonee 2005; Hammer and Schmidlin 2002; Schmidlin et al. 2009). The interviews were advertised broadly, through both online channels (e.g., thematic Facebook groups) and traditional media (e.g., print newspaper and local radio station). Second, a confirmatory questionnaire survey was developed based on insights gained from the interviews and was disseminated to a larger sample. This blended methods approach was utilized to probe respondents' perceptions of tornado risk, as well as their complex motives for protective-action decision making during the two severe weather events. An overview of the entire study is provided in Silver (2012).

This paper draws on findings from the 32-item questionnaire, particularly as they relate to the theme of protective action. The questionnaire was structured similarly to the interview script, and contained questions on general weather knowledge, the 21 August 2011 tornado, the 24 August 2011 storm system, and long-term impacts and recovery. The questionnaire was advertised in three ways. First, an online version of the questionnaire went live on 27 December 2011 and remained available until 15 March 2012. A recruitment script for the online survey was posted to the Facebook groups that had been previously used to advertise for the interviews. Second, an undergraduate student researcher conducted a systematic random sample through a door-to-door survey during two weekends in February 2012. In this random sample, every fifth residential home on 12 randomly selected streets was visited to solicit participation in the study. If no one was home at the time of the visit, the student researcher left an information letter that explained the research project and provided the hyperlink to the online questionnaire. Finally, paper copies of the questionnaire were printed and left at the Goderich Public Library by a visible display that contained information on the research project. Individuals who completed these questionnaires placed them in a sealed envelope and left them with library staff for pick up.

A total of 304 questionnaires were received by the closing date of 15 March 2012. The questionnaire data were downloaded from Surveymonkey.com and formatted for analysis in both spreadsheet and statistical software. Response summaries are provided in graphical and tabular form, and differences in response patterns across respondent groups are examined using chi-square analysis and z tests. For the latter, differences that are statistically significant at a 95% confidence level are reported, and the p values are included in summary tables.

4. Results

a. Respondent characteristics

As the primary purpose of this paper is to examine the influence of previous disaster experience and sociodemographics on protective-action decisions during two successive disaster scenarios, the relevant sample

TABLE 1. Demographic characteristics of the questionnaire respondents who experienced both storms ($n = 151$), compared to the 2006 Statistics Canada community profile for Goderich (Statistics Canada 2012).

	Statistics Canada	Questionnaire
Age (median)	45.6	40–49
Gender (% female)	53	72
Education (% with high school diploma)	27	22
Education (% with university or college diploma)	36	36
Income (median, $)	63 965	50 000–74 999
Residential status (% Goderich resident >5 yr)	62	68

for this paper includes two groups of respondents: 1) those individuals who were in Goderich on 21 August 2011 and 24 August 2011 who also provided information on their protective-action decisions ($n = 151$) and 2) those individuals who were in Goderich only on 24 August 2011 who also provided information on their protective-action decisions ($n = 26$). The first group represents the subset of respondents who directly experienced the tornado event, while the second group represents a group of local residents who were not in town during the tornado touchdown but witnessed the aftermath of the storm. These two groups combined represent those participants who were in Goderich for the subsequent tornado watch and warning on 24 August 2011.

The sample characteristics were examined relative to other studies and also to the town's demographics. The sample size ($n = 177$) is comparable to that of several other studies conducted on public perception of and response to severe weather (e.g., Comstock and Mallonee 2005; Silver and Conrad 2010; Zhang et al. 2007; Balluz et al. 2000; Sherman-Morris 2005; de Man and Simpson-Housley 1987; Wong and Yan 2002; Hammer and Schmidlin 2002). To explore the generalizability of the results, the sociodemographics of the sample were compared to Statistics Canada's 2006 Community Profile for Goderich (Table 1). Although females are overrepresented in this study, it is common for women to respond to questionnaires more often than men (e.g., Sax et al. 2003; Underwood et al. 2000). The other sociodemographic characteristics were similar between the sample and the census.

b. Protective action taken

For both events, respondents were asked whether they took protective actions. Given the severity of the tornadic event on 21 August, and the presence of many visual and auditory cues, it was anticipated that many residents would have taken protective action—even if only in a reactive mode. Furthermore, if the 21 August tornado resulted in heightened sensitivity in the community on 24 August 2011, then we hypothesize that many individuals would have taken protective action following the issuance of a tornado warning in late afternoon, even though the observed weather was less threatening. Responses to this binary variable are summarized in Table 2.

1) 21 AUGUST TORNADO—SEVERE WEATHER WATCH, TORNADO WARNING, AND TOUCHDOWN

As shown in Table 2, 58 of the 151 (38%) respondents who were in Goderich on 21 August 2011 when the tornado struck took protective actions. When asked what cues motivated their decisions to take protective action, dominant responses included seeing objects (e.g., lawn furniture, tree branches) being thrown around outside ($n = 32$), hearing the wind/rain/hail become very intense ($n = 48$), and seeing trees bending/breaking in the wind ($n = 36$); the full range of reported motivational cues are summarized in Fig. 3. Since a tornado had never previously affected this community—and indeed the closest other major tornado occurred 15 yr earlier over 150 km away—this may represent the propensity of those with no prior tornado experience to take protective action when confronted with strong visual and auditory cues of severe weather.

TABLE 2. Comparison of protective-action decisions made on 21 and 24 Aug for those individuals who experienced both events ($n = 151$) and for those individuals who only experienced the 24 Aug 2011 event ($n = 26$).

	Respondents who took protection action on			Respondents who did not take protective action	Group size
	21 and 24 Aug	21 Aug only	24 Aug only		
Respondents who were in the study area for both events	40	18	45	48	151
Respondents who were in the study area for 24 Aug only	—	—	15	11	26
Total sample for analysis	40	18	60	59	177

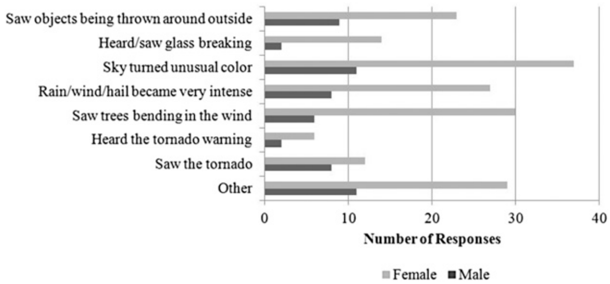

FIG. 3. Factors (not mutually exclusive) that motivated individuals' protective-action decisions during the 21 Aug 2011 tornado.

Next, respondents were asked about whether they received the Environment Canada tornado warning. Only 12 of the 151 participants (8%) who were in the Goderich region on 21 August 2011 received the warning. Although this figure is fairly low, the 12-min lead time may have been too short for many people to seek warning information before the tornado struck. The lack of warning infrastructure in the region (such as outdoor warning sirens and/or automated text alerts) may also have contributed to the low awareness of the tornado warning. Of the 12 respondents, 8 reported that they took protective action, but only 1 person was prompted to do so by the warning in isolation of other visual and auditory cues. The other 7 people, who received the warning and who took action, indicated that audiovisual cues were their primary motivations. As discussed previously, these physical cues were also the reasons why those who were not aware of the tornado warning decided to take protective action. Thus, the findings indicate that those individuals who took protective action during the tornado generally agreed that it was in response to the violent weather that they saw or heard.

Of those who did not take protective action during the storm, approximately one-half indicated that they did not realize there was a tornado on the ground. Other common reasons for not taking protective action included the following: it happened too quickly to do anything ($n = 29$) and the weather did not appear to be that severe ($n = 18$). Eleven respondents indicated that they were unable to shelter for a variety of other reasons (e.g., because they were at work or because they were in a vehicle), while five respondents said that they would have taken shelter but they had no safe place to go. Only one person indicated that she chose not to take shelter because she wanted to see the tornado.

2) 24 AUGUST—WARNING DISSEMINATION AND HAZARD AWARENESS

The circumstances of 24 August 2011 unfolded differently than what had transpired 3 days earlier. As a result of the destruction caused by the tornado, both local and national media (e.g., newspaper, radio, television, and electronic news) ran frequent coverage of the Goderich tornado. Social media was similarly inundated with pictures, videos, and personal accounts of the destruction. For example, the Facebook group ''Goderich Ontario tornado victims and support'' hosted by the United Way had 7000 followers within 12 h of the tornado. Within one week, it had over 47 000 unique people who had interacted with the group and over 2.9 million views of the stories posted in its news feed (United Way 2012).

When asked about their situational awareness on 24 August 2011, the majority of respondents who were in Goderich ($n = 177$) indicated that they checked the weather more often than usual that day (79%, 140/177), and most respondents agreed they learned about the tornado watch soon after it was posted (74%, 131/177). Similarly, most respondents agreed that people were talking about the weather all day (74%, 131/177) and that community members were being hypervigilant about the weather conditions (81%, 143/177). Based on this information, it is possible to conclude that there was a high degree of sensitivity and social amplification of risk present among many respondents during the 24 August 2011 storm event.

The short time span between the 21 August tornado and the 24 August storm provides a unique opportunity to explore how previous disaster experience influences individual behavior. Based on the survey findings, there is strong evidence that the experience of the 21 August tornado positively influenced the behavior of Goderich residents 3 days later. The data suggest that protective action was more pervasive on 24 August than on 21 August, even though the weather system itself did not produce the same visual cues that prompted most of the protective action on 21 August 2011.

Of the respondents who were present for both events, 56% (85/151) took protective action on 24 August, a significant increase ($z = 3.11$, p value $= 0.001$) over 21 August, where only 38% of this group (58/151) took protective action. Interestingly, a similar percentage of respondents (15/26 = 58%) who were in the study area only on 24 August took protective action during this storm. The likely explanation is that the aftermath of the tornado had a strong effect on local-area residents, regardless of whether they had directly experienced the tornado itself. This is reinforced by the fact that the damages incurred by the two groups were similar (Table 3).

There is also evidence to suggest that the tornado watch and warning were the main stimuli for protective-action

TABLE 3. Comparison of household injuries, household damages, and property damages between those individuals who experienced both events ($n = 151$) and those who only experienced the 24 Aug 2011 storm ($n = 26$).

	Present for both events ($n = 151$)		Present only on 24 Aug 2011 ($n = 26$)	
	n	%	n	%
Household sustained injuries (serious or minor)	5	3.3	1	3.8
Home sustained damages (serious or minor)	39	25.8	6	23.1
Property sustained damages (serious or minor)	60	39.7	6	23.1

TABLE 4. Chi-square values (X^2) and chance probability values for the influence of demographics on decision making for 21 and 24 August.

	Protective-action decisions on 21 Aug 2011			Protective-action decisions on 24 Aug 2011		
	X^2	d	p value	X^2	d	p value
Gender	0.66	1	0.42	5.94	1	0.01
Age	1.60	4	0.81	7.74	4	0.10
Education	14.85	3	0.69	4.00	3	0.26
Income	2.72	5	0.74	9.11	5	0.10
Residential status	5.65	2	0.06	1.52	2	0.47

decision making on 24 August 2011. Of the 177 respondents who were in Goderich during this storm, 57% (100/177) agreed that they took protective action once Environment Canada upgraded the tornado watch to a tornado warning.

Although there was an observed community-wide improvement in protective behaviors during the 24 August 2011 storm, 18 individuals who were in the study area during both storms indicated that they took protective action during the tornado but not during the subsequent storm. Most of these respondents felt that it was unlikely that a second tornado would hit Goderich and/or that they felt confident in their own ability to determine whether to take protective action. Also, there was a sense among some respondents that community members generally overreacted to the watch and warning postings on 24 August 2011. Approximately 31% (54/177) of the respondents felt that most people overreacted when the tornado watch was posted, and 28% (50/177) of the respondents indicated that they were not worried about the tornado watch because they thought it was unlikely that a second tornado would impact the town. Additionally, 44% ($n = 77$) of respondents did not take protective action when Environment Canada upgraded the tornado watch to a tornado warning. These results suggest that, despite their recent experience (either direct or indirect) with a damaging tornado, a substantial portion of the respondents trusted their own risk judgments above those of Environment Canada.

Despite the number of respondents who did not take protective action on either day, it is important to note that, of those respondents who experienced both events, the proportion who took protective actions on the second event was approximately 18% higher than on the first day. Thus, previous disaster experience seemed to positively influence protective-action decisions for some individuals.

c. *Demographics variables and protective action*

This next section explores the influence of sociodemographic variables on protective-action decision making. The focus is on the 151 survey respondents who were in the study area for both events. As shown in Table 4, in most cases protective action is not statistically associated with individual sociodemographic variables. The exception is gender for 24 August 2011 only. In this case, the findings confirm what has been found in previous studies—namely, that females are more likely to take protective action when warned than males (e.g., Sorensen 2000; Sherman-Morris 2005, 2010; Murphy et al. 2005). Figures 4a–e summarize the responses on protective actions broken out by sociodemographic variables. As illustrated here, even while most associations are not statistically significant, partly due to a modest sample size, the patterns suggest that—on both dates—females are more likely than males to take protective action; young adults are less likely than older adults to take protective action; those with comparatively low levels of education are less likely than others to take protective action; and finally, those who are visitors or newcomers to a community are less likely than long-time residents to take protective action.

5. Discussion

a. *Influence of previous disaster experience during subsequent events*

There was a substantial increase in the number of respondents who took protective actions during the subsequent severe storm on 24 August 2011. This indicates that there was either some degree of community-wide learning or an increased sensitivity among respondents as a result of the tornado. This finding corroborates the results of Comstock and Mallonee's (2005) research, which is the only other known study to examine the influence of previous disaster experience on protective behaviors during two successive tornadic events within a single community.

Interestingly, the percentage of individuals who took protective action on 24 August 2011 was not significantly different ($z = -0.13, p$ value $= 0.45$) between those who experienced both storms (56%) and those who experienced only the subsequent storm (58%). This finding was unexpected, and it seems to contradict previous research that found that direct experience with hazards has a greater effect on risk perception and/or protective behaviors than indirect experience (e.g., Paton et al. 2000; Blanchard-Boehm and Cook 2004; Anderson-Berry 2003). This finding may be partially explained by processes relating to the social amplification of risk (Kasperson et al. 1988). After the 21 August 2011 tornado, traditional media (e.g., newspapers, radio, and television) and social media were inundated with pictures, videos, and personal accounts of the disaster. Many of the questionnaire respondents reported high levels of weather saliency on 24 August 2011. The vast majority of respondents agreed they had learned about the tornado watch soon after it was posted, and respondents agreed that people were both talking and being ''hypervigilant'' about the weather all day. Hence, risk information was both voluminous and dramatized on 24 August 2011, which may provide an explanation for why individuals with indirect experience reacted similarly as those with direct experience.

These findings regarding the influence of direct and indirect previous disaster experience on self-protective decision making highlight the nebulous and diverse nature of previous disaster experience. Furthermore, the present study highlights the complicated relationship between previous disaster experience and social amplification of risk on the decision-making process during subsequent events. For example, it is difficult to be certain whether respondents took protective action on 24 August 2011 because 1) the tornado watch and warning were issued well in advance of the storm, 2) they had previously experienced a damaging disaster (either directly or indirectly), or 3) risk perception was amplified due to increased situational awareness. Although many existing studies on hazard perception and response discuss the influence of previous disaster experience and/or risk perception, few successfully unpack the complicated relationship among these variables.

b. *Tornado warning lead times*

The tornado warning lead times varied significantly between the two storms. On 21 August 2011, residents had approximately 12 min between when the tornado warning was issued and when the tornado impacted the town. On 24 August 2011, there was over 6 h between the time the first tornado watches were posted and when the tornado warning was posted for Goderich. It is possible that the higher percentage of respondents who reported taking protective action on 24 August 2011 may be partially attributable to the greater time between when the tornado watch was posted and when the storm arrived. However, reported differences in motivational cues and in ambient weather conditions on the two days suggest that the longer lead time was not solely responsible for the increase in protective behaviors between the two events.

Questionnaire respondents who took protective action during the 21 August 2011 tornado agreed that they did so in response to threatening or disturbing audiovisual stimuli (e.g., objects being thrown around outside; trees bending/breaking in the wind). Of the 12 respondents who received the tornado warning, 11 agreed that their protective actions were at least equally motivated by physical cues. This finding is supported by Sorensen's (2000) review of the hazard literature, which found a high level of empirical support for physical cues as motivators of protective action. In contrast, the conditions in Goderich on 24 August 2011 were quite different. Although the storm produced heavy rain, the conditions were not as severe as they had been during the 21 August 2011 storm. Accordingly, residents were not exposed to the same degree of audiovisual cues that had been present during the tornado. Yet despite the lack of motivating physical cues, almost half of the respondents took protective action when Environment Canada upgraded the tornado watch to a tornado warning. In comparison, only one respondent indicated that she took protective action during the 21 August 2011 tornado as a result of the tornado warning. This finding suggests that respondents were more likely to rely on official warnings (rather than environmental cues) on 24 August 2011 due to their increased sensitivity and/or increased forecast credibility.

c. *Respondent demographics*

Although sociodemographics are commonly cited in the literature as being correlated with protective decisions, few of these variables were found to be significant in the present study. For the 21 August 2011 tornado, none of the tested sociodemographic variables (e.g., gender, age, household income, employment

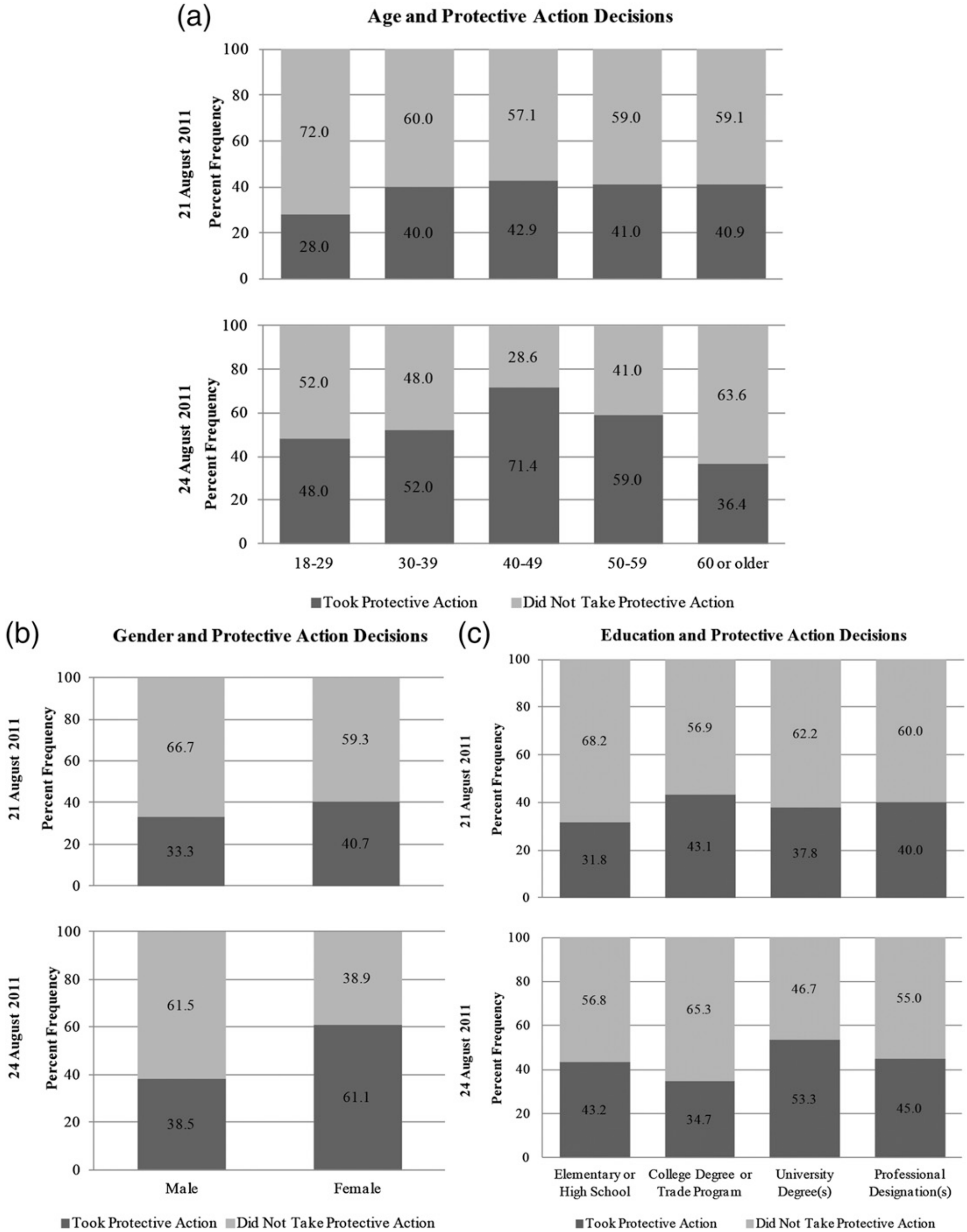

FIG. 4. Influence of various sociodemographic variables on protective-action decisions for those individuals who were in both storms ($n = 151$): (a) age, (b) gender, (c) education, (d) household income, and (e) residential status.

category, or residential status) was found to be statistically significant. This result was initially surprising, and it contradicts a well-established literature that shows that gender, education, and socioeconomic status are generally good predictors of protective decisions (e.g., Sorensen 2000). This result may be partially attributable to the sudden onset of the 21 August 2011 disaster. As most of the respondents did not receive the tornado warning, their decision to take protective action was highly reactionary in response to threatening physical cues. In comparison, females were more likely to take protective action than males on 24 August 2011. While

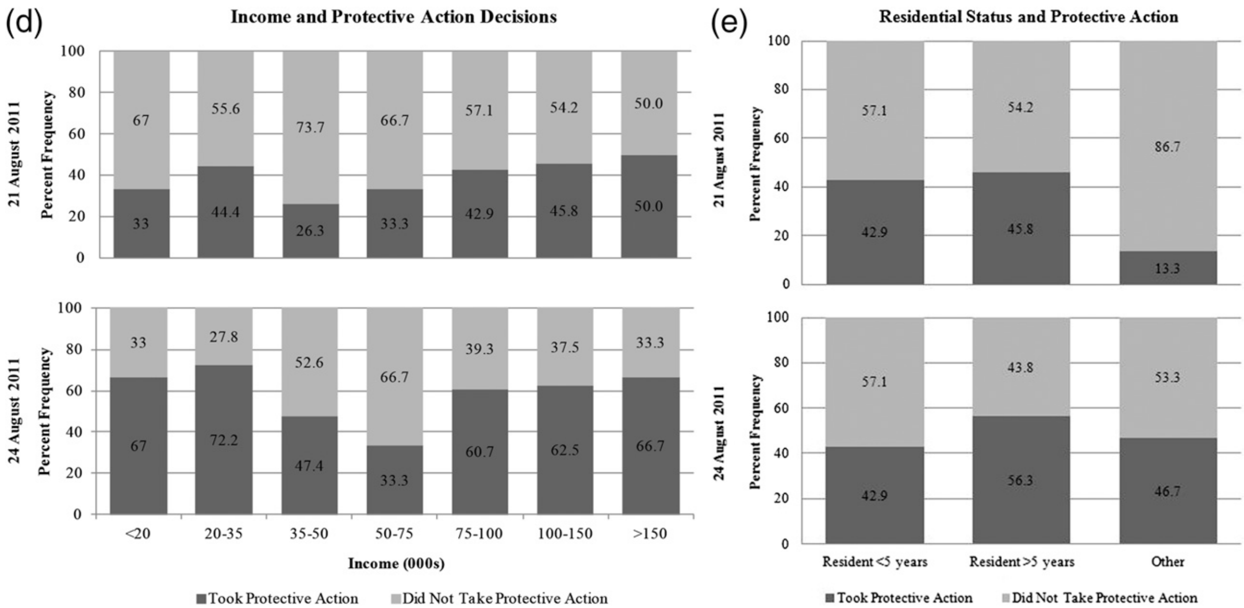

FIG. 4. (*Continued*)

other sociodemographic variables did not meet statistical significance, the patterns themselves were mostly consistent with previous studies. It is possible that the sample size was sufficient to recognize categorical differences in sociodemographic variables but insufficient to achieve statistical significance.

d. *Study limitations*

Although Goderich, Ontario, is located in a region at risk for damaging tornadoes, there was no history of tornadic activity in or around the community prior to 21 August 2011. Thus, the results of this study are based on a sample group with effectively zero experience with tornado hazards. Therefore, caution should be exercised before generalizing the results of this study to those communities with more experience with tornado events.

6. Conclusions

It has been established that previous disaster experience and sociodemographics intersect with the decision-making process in many complex ways. The findings of this research corroborate previous studies that found that recent previous disaster experience may positively influence protective-action decisions during successive events. However, the long-term influence of previous disaster experience on protective-action decision making remains uncertain. Additionally, this research suggests that both direct and indirect previous disaster experience may influence warning compliance during high-risk events. Finally, it was found that gender (female) influenced protective-action decision making with previous disaster experience. Future research may benefit from clearly defining and unpacking the influence of both previous disaster experience and sociodemographics in their methodology.

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