

Exploring the Interplay Between Threat Appraisal, Efficacy Appraisal, and Behavior Change During a “Once-in-a-Lifetime” Storm

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ABSTRACT

In 2022, Hurricane Fiona made landfall in Atlantic Canada, causing widespread destruction across the region. The storm provided the opportunity to test the Extended Parallel Process Model (EPPM), which predicts that warning messages influence threat appraisal and efficacy appraisal, and in turn influence whether individuals engage in fear control processes or danger-control processes. To do so, a questionnaire was disseminated to residents of Atlantic Canada (n=582) approximately two weeks after the storm. The results find that respondents generally fell in one of two protective action classes: low protective action and high protective action. Efficacy appraisal had no effect on whether or which actions respondents took during the storm. In contrast, anxiety and information seeking were both found to be significant. The results seemingly contradict previous research on fear appeals guided by the EPPM. In our conclusion, we speculate on why this may be and recommend several opportunities for future research.

Keywords

Protective action decision-making; coastal disasters; survey research; latent class analysis; crisis management

INTRODUCTION

Witte's (1992) Extended Parallel Process Model provides insight into the ways that individuals respond to fear-inducing messages, such as warning messages. According to the EPPM, individuals undergo two related processes when confronted with a potential or impending threat: threat appraisal and efficacy appraisal. If individuals have high threat appraisal (HTA) and low efficacy appraisal (LEA), they will be more likely to engage in emotion-focused coping strategies to reduce feelings of distress, fear, confusion, and helplessness (e.g., Witte 1992). In contrast, if individuals have high threat appraisal (HTA) and high efficacy appraisal (HEA), they will be more likely to engage

problem-focused coping strategies to prepare for and mitigate against a potential threat.

When Hurricane Fiona developed in 2022, there was a great deal of discussion, both online and offline, about its potential impacts in Atlantic Canada. Meteorologists and forecasters warned residents that the storm could be a once-in-a-lifetime event and to prepare accordingly. In the days leading up to landfall, local, national, and international news media heralded the storm as “historic”, “fearsome”, “deadly”, and “dangerous”. This raised question about whether and how these messages (i.e., fear appeals) would affect the way Atlantic Canadians perceived, and in turn, prepared for and responded to the storm. Accordingly, this paper presents results of a questionnaire that was distributed in Atlantic Canada approximately two weeks after the storm made landfall. The questionnaire examines the interplay between threat appraisal, efficacy appraisal, and behavior change during a destructive coastal storm. The paper begins with a literature review that summarizes existing research on the psycho-social process of coping and introduces Witte’s (1992) Extended Parallel Process Model. Next, we present the case study of Hurricane Fiona and its impacts in Atlantic Canada. Sections 4 and 5 describe our methodology (i.e., survey design, sample selection, and latent class analysis) and our results, respectively. Lastly, the discussion section contextualizes these results within the broader literature and concludes with some suggestions for future research. To the best of our knowledge, this study is the first to examine EPPM in the context of a landfalling Canadian hurricane. It thus builds upon and expands existing research on threat appraisal, efficacy appraisal, and behavioral change in the context of coastal storms.

BACKGROUND

Coping

The psycho-social process of coping, which includes the ways that people cope, the effectiveness of those methods, and any associated emotions, has been the subject of considerable academic research. Folkman and Lazarus (1980:223) define coping as “...the cognitive and behavioral efforts made to master, tolerate, or reduce external and internal demands and conflicts among them”. This definition highlights coping as the attempt to resolve problems (i.e., actual or perceived threats, traumas, or stressors) that people have already encountered or are actively anticipating. In addition to problem-solving, coping is a process through which people attribute meaning to an event, make sense of an event, find benefit from the event, and/or maintain emotional balance (Algorani and Gupta 2021; Davis and Nolen-Hoeksema 2001; Folkman and Lazarus 1980; Folkman and Moskowitz 2004; Stephens et al. 2012).

Coping is often understood to operate across four strategies: meaning-focused coping, social coping, problem-focused coping, and emotion-focused coping (Algorani and Gupta 2021). Meaning-focused coping allows individuals to derive and manage the meaning of a situation by utilizing cognitive strategies (Algorani and Gupta 2021; Folkman and Moskowitz 2004). Meaning-focused coping is typically used to cope with events that are uncontrollable or unfixable by employing problem-focused strategies (Folkman and Moskowitz 2004). Similarly, social coping (also known as support seeking) is used by individuals who seek out emotional or instrumental support from others to reduce stress (Algorani and Gupta 2021; Parkinson et al. 2020). Social coping can provide individuals facing stressful events with a protective factor for mental health through positive interactions, affirmation, and assistance (Parkinson et al. 2020). In contrast, problem-focused coping deals with the source of stress that affects a person’s relationship with their environment and is typically undertaken when a person believes they can resolve a problem (Algorani and Gupta 2021; Folkman and Lazarus 1980). Lastly, emotion-focused coping involves controlling, reducing, or eliminating the emotions related to or brought about due to the stressor, and it commonly occurs in situations that must be accepted (i.e., where actions will not resolve the problem) (Folkman and Lazarus 1980; Folkman and Moskowitz 2004; Scott et al. 2010).

The ability of people to cope with and recover from stressful events, and the methods they employ to do so, are affected by numerous endogenous and exogenous factors, including: personal dispositions; feelings of uncertainty or uncontrollability; presence or absence of external supports; one’s worldviews, culture, religious beliefs, and/or faith; and the event itself (e.g., Ai et al. 2022; Davis and Nolen-Hoeksema 2001; Ekanayake et al. 2013; Folkman and Lazarus 1980; Folkman and Moskowitz 2004; Haque et al. 2023; Neubaum et al. 2014; Scott et al. 2010).

Extended Parallel Process Model (EPPM)

Research on coping and coping appraisal influenced the development of Witte’s (1992) Extended Parallel Process Model (EPPM), which explains how fear-inducing messages (such as warning messages) motivate individual behavior change. In this context, fear was operationalized as “...anxiety (i.e., self-rated feelings of anxiousness), physiological arousal, responses to mood adjectives (e.g., frightened, anxious, nauseous), and ratings of concern or worry” (Witte

1992: 331). Importantly, fear can be triggered either by the event itself (i.e., direct experience) or by messaging about the event (i.e., indirect experience).

The model begins with the appraisal of a perceived threat. As explained by Witte and Allen (2000: 592), perceived threat "...is composed of two dimensions: perceived susceptibility to the threat (i.e., the degree to which one feels at risk for experiencing the threat) and perceived severity of the threat (i.e., the magnitude of harm expected from the threat)". If this appraisal results in a moderate to high perceived threat, then the second appraisal begins: the evaluation of self-efficacy and response efficacy surrounding the recommended response. In the disaster literature, self-efficacy can be conceptualized as "...the extent to which individuals believe they are capable of coping with the threat", whereas response efficacy refers to "...the extent to which individuals believe that response measures suggested will be effective in averting the threat" (Zhang et al. 2022: 2).

Although Witte does not provide a standalone definition of 'behavior change' in this context, she delineates two types of behaviors that may be motivated by these appraisals: danger control processes and fear control processes. When perceived threat and perceived efficacy are high, an individual will engage in danger control processes (i.e., problem-focused coping). Danger control processes in the context of coastal storms might include things such as purchasing supplies, boarding windows, sandbagging, and seeking out information (Ai et al. 2022; Algorani and Gupta 2021; Ekanayake et al. 2013; Spence et al. 2007). As a result of undertaking these actions, individuals commonly experience lower levels of fear, anxiety, trauma, or distress (Witte 1992). For example, research on flood hazards in Australia (Pritchard and Gow 2012) and the 1999 Marmara earthquake in Turkey (Sumer et al. 2005) both found that higher levels of coping self-efficacy were associated with lower levels of psychological distress among respondents.

In contrast, when perceived threat is high and perceived efficacy is low, an individual's fear processes are dominating and, thus, they are more likely to perform fear control processes (i.e., emotion-focused coping strategies). In the context of coastal storms, emotion-focused coping might include denial, avoidance, wishful thinking, religious meaning-making, seeking/offering emotional support, and fatalism. As explained by Grothmann and Reusswing (2006: 106):

Protective responses are those that prevent monetary or physical damage if an event actually occurs, and are taken if the threat appraisal and coping appraisal are high. Non-protective responses – including denial of the threat, wishful thinking and fatalism --- do not prevent monetary or physical damage, but only the negative emotional consequences of the perceived risk, such as fear. **A person would take non-protective responses if his or her threat appraisal is high, but the coping appraisal is low.** (*emphasis added*)

Further Theoretical Considerations

While the EPPM provides crucial insight into the ways that threat appraisal and efficacy appraisal affect behavioral change, it is not the only model to do so. The Protective Action Decision Model (Lindell and Perry, 2012) also provides insight into the ways that threat perceptions, efficacy perceptions, and stakeholder perceptions affect behavioral response. This model has been successfully applied to research involving a wide variety of hazards and disasters, including extreme heat (e.g., Beckmann et al., 2021), floods (e.g., Terpstra and Lindell, 2012) infectious disease (e.g., Silver et al., 2024; Sun et al., 2023), industrial hazards and accidents (e.g., Heath et al., 2018; Liddell et al., 2020), and tropical cyclones (e.g., Huang et al., 2016; Li et al., 2024; Zhang and Borden, 2024). While the present study examines fear appeals in the context of the EPPM, the PADM provides an interesting (and influential) alternative for comparison.

Present Study

To further explore the relationship between threat appraisal, efficacy appraisal, and behavioral change, we examine the case of Hurricane Fiona, which affected Atlantic Canada in September 2022. In the days leading up to landfall, the storm was described by local, national, and international news outlets as a "record-breaking", "dangerous", "once-in-a-lifetime" event. Accordingly, Hurricane Fiona provided the opportunity to examine how threat appraisal and efficacy appraisal intersected with one another to influence whether and how Atlantic Canadians responded to this storm. To achieve the stated purpose of this paper, we examine three related research questions:

1. How was Hurricane Fiona perceived by respondents? More specifically, which storm-related hazards (e.g., storm surge, rainfall, wind speed) and impacts (e.g., property damage, community damage, personal injury) were respondents most concerned about?
2. Did respondents generally display high or low levels of self-efficacy? If so, which socio-demographic variables, if any, are most often associated with self-efficacy?

3. Did threat appraisal and efficacy appraisal affect behavioral change in ways that are consistent with the EPPM? If not, what variables, if any, better predict behavioral change?

CASE STUDY: HURRICANE FIONA

Hurricane Fiona made landfall in Nova Scotia, Canada on 24 September 2022 as a post-tropical storm with approximately 44.7 m s^{-1} wind speeds (Pasch et al. 2023). The storm caused significant damage in Nova Scotia, particularly in eastern portions of the province (e.g., Antigonish and Guysborough Counties, Cape Breton Island), with substantial damage also reported in central Nova Scotia and Prince Edward Island. The storm continued to weaken as it tracked northwards through the Gulf of St. Lawrence, passing between Newfoundland and Labrador. The position of the storm, coupled with local geography, meant that southwestern Newfoundland experienced a significant storm surge that damaged or destroyed 100 homes and displaced 200 people (CBC 2022). As a result of the storm, over 500,000 customers lost power in the region, which accounted for approximately 80% of residents in Nova Scotia and 94% of residents in Prince Edward Island (NBC News 2022). In total, the Insurance Bureau of Canada has estimated that Hurricane Fiona caused over \$800 million CAD in insured losses, making it the costliest storm to ever affect Atlantic Canada and the seventh costliest storm in Canadian history (IBC 2023).

In the days preceding Hurricane Fiona's arrival in Atlantic Canada, the storm received a significant amount of attention from both the public and private weather enterprise, and subsequently, national and international news media. The Canadian Hurricane Center (CHC) began issuing its first public bulletins about the storm as early as 20 September 2022, wherein they warned of "significant impacts" in eastern Canada (@ECCC_CHC 2022). Shortly thereafter, Hurricane Fiona made history as the strongest northernmost Atlantic hurricane on record, a fact that garnered significant attention on social media (e.g., Burg 2022). As forecasts began converging on likely conditions and impacts in the region, Fiona began making headlines across Canada with news agencies referring to Fiona as "historic", "record-breaking", "deadly", and "dangerous" in the days leading up to landfall (e.g., CBC News, 2022a,b,c). Additionally, many news agencies drew direct parallels between Hurricane Fiona and past storms that caused widespread destruction in the region, such as Hurricane Juan (e.g., CBC News 2022b,c), Hurricane Dorian (CBC News 2022a; Weather Network 2022), and Hurricane Sandy (Yahoo News 2022).

Accordingly, Hurricane Fiona is a suitable case study for exploring the interplay between threat appraisal, efficacy appraisal, and behavioral change for two reasons: firstly, the storm received a significant amount of media coverage in the days leading up to landfall, which may have affected residents' perceptions of risk and, subsequently, their emotional reaction -- two important components of the Extended Parallel Process Model (Witte, 1992). Secondly, the population of Atlantic Canada is generally older and more rural with higher rates of disability and lower household income compared to the Canadian national average (CBC News 2024; Statistics Canada 2022; Statistics Canada 2024). These factors can influence efficacy appraisal, another component of the EPPM, which in turn may influence the coping strategies one might employ during a disaster.

METHODS

Survey design and sample selection

This study utilized a questionnaire instrument containing both close-ended and open-ended questions that explored issues relating to risk perception, self-efficacy, anxiety, information-seeking, and behavioral response in the context of Hurricane Fiona. Questions were both drawn from previous studies (e.g., Silver et al., 2022; Silver and Behlendorf, 2023) and developed from existing theory. The full survey instrument is available from the corresponding author upon request. The questionnaire was distributed by Qualtrics, an on-line survey provider, to panelists living in Nova Scotia, Prince Edward Island, and Newfoundland, and it was live from 10 October 2022 to 24 October 2022. Qualtrics was chosen for survey distribution because it is quick, efficient, and allows for broad geographic sampling – a notable benefit, given Atlantic Canada's large size and (relatively) low population density. Lastly, this research was reviewed and approved by the University at Albany's Institutional Review Board (IRB) for research involving human subjects.

Initially, 848 participants were invited to be a part of the study. However, after data cleaning protocols were undertaken, which included the removal of anyone who did not complete at least 70% of the questionnaire, completed the questionnaire in less than half of the median time, and/or entered gibberish into the open-ended question fields, we were left with a final sample of 582 questionnaires for analysis. As outlined by Table 1, our sample has a smaller proportion of female respondents, fewer younger respondents (i.e., aged 18 to 28-years-old), and a higher average household annual income compared to the 2021 census for the Atlantic region. To answer our research questions, we

used a variety of descriptive statistics (frequencies, means, etc.) to elucidate overall patterns, and leveraged Chi-square analysis to evaluate statistically significant differences in those patterns, as well as a latent class analysis to examine protective action decision-making.

Table 1: Socio-demographics of the Sample

Characteristic	Valid Responses	N (%)	% 2021 Census
Female	568	274 (48%)	50.5
Age Group	582		
18-29		54 (9.3%)	19.1 ^a
30-39		101 (17.4%)	13.5
40-49		87 (14.9%)	14.0
50-59		115 (19.8%)	17.1
60 years or older		225 (38.6%)	36.2 ^b
Household Income	570		
Less than \$20,000		55 (9.6%)	21.1
\$20,000 to \$39,999		115 (20.2%)	32.2
\$40,000 to \$59,999		118 (20.7%)	21.2
\$60,000 to \$79,999		86 (15.1%)	13.7
\$80,000 to \$99,999		61 (10.7%)	7.9
\$100,000 or greater		135 (23.7%)	7.5

^a Due to the limitations of the Canadian census, this value includes 15 to 29-year-olds.

^b Although we collected age data for '60-69 years-old' and '70 years and older', the Canadian census reports only values for '60-64 years', '65 years and older', and '85 years and older'.

Latent Class Analysis

Given that protective action items were displayed to respondents in a check all that apply framework, that means there are $2^{12} = 4,096$ theoretically possible combinations of protective actions that individuals could have engaged in. Indeed, not all of these theoretically possible combinations of protective actions were observed in these data, but 150 different patterns were still observed. A dependent variable with 150 possible options for a sample of 576 observations is clearly untenable. An alternative strategy to leverage the patterns of protective actions is necessary to link threat appraisal and self-efficacy to protective actions. One such strategy lay in latent class analysis, a special form of mixture modeling where we consider our observed data to be a product of several distributions as opposed to a single distribution. Stated differently, rather than assuming all individuals are from a single protective action distribution, we think there could be several underlying subpopulations of protective action that are represented in our data. Latent class analysis is ideal for unpacking potential unobserved heterogeneity in a set of categorical variables with the classical case involving 0/1 dummy variables akin to those here for protective action. This method has also been viewed as a data reduction technique where the large number of patterns can be represented by a smaller number of latent classes. Latent class analysis has an advantage over traditional clustering techniques in that we do not have to definitively assign any individuals to a single class and instead link them to all classes probabilistically. For our purposes here, it is ideal for enabling us to see how threat appraisal, efficacy appraisal, anxiety, and information seeking are related to different patterns of protective action.

A first step in latent class analysis is to discern the optimal number of latent classes to represent the patterning in the protective action items. Table 2 provides the model selection and model fit information for 2, 3, 4, 5, and 6 class models. An optimal latent class model will be the one with the lowest AIC, lowest BIC, average posterior probability of class membership greater than .85 (.70 is the satisficing threshold), and the smallest latent class that reflects more than 5% of the sample. As we look through Table 2, we can see that the BIC prefers the two-class solution while the AIC is preferring a six-class model that has very poor model diagnostics. The smallest class and lowest average posterior probability of class membership for the six-class solution are well below acceptable tolerances for model fit. It would seem the penalty for additional classes in the AIC is not severe enough in these data, prompting the AIC to prefer more classes even though the resulting solution is of poor quality. Given the BIC unequivocally prefers the two-class solution, and that this two-class solution has excellent model diagnostics with very high average posterior probabilities of class membership, we move forward with the two-class model as being the best latent class model to represent these data. Class 1 represents 40.28% of the data and Class 2 represents 59.72% of the data. We will return to the protective action latent classes later in the results section.

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Table 2. Model Selection Information

Number of Classes	AIC	BIC	Minimum Class %	Average Posterior Probability of Class Membership
2	5602.238	5711.141	40.28	.90155
3	5575.204	5740.736	22.22	.78158
4	5540.892	5763.053	20.83	.73684
5	5546.355	5825.146	15.1	.73326
6	5515.43	5850.85	1.74	.04120

NOTES: AIC and BIC values in bold were the “best” fitting models according to the respective information criterion.

RESULTS

Threat Appraisal

In order to gauge threat appraisal, we asked respondents to indicate to what extent they were concerned about storm-related hazards and potential impacts. In terms of storm-related hazards, respondents were most concerned about high winds ($p = 0.01$) with 83% of the sample indicating they were “very concerned” ($n=350$, 60%) or “somewhat concerned” ($n=136$, 23%) about wind. Rainfall was also a concern, although less so than high winds, and respondents were generally less concerned about flooding and storm surge (Figure 1). In terms of potential impacts, respondents were most concerned about power outages, damage to one’s community, and damage to one’s personal property (Figure 2). The potential for personal injury and/or being unable to work because of the storm were much less concerning for respondents.

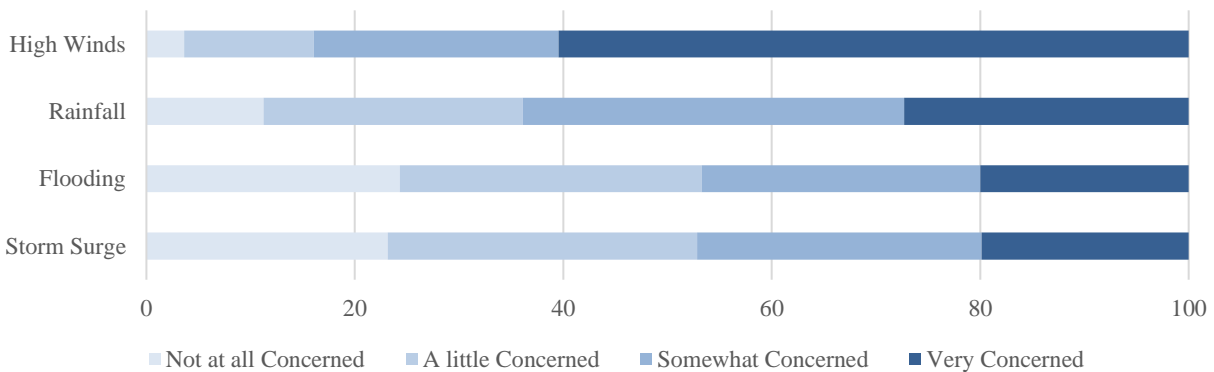


Figure 1: Concern by Hazard Type

Fear

As the EPPM predicts that threat appraisal will affect fear, which Witte (1992:331) operationalized as “...anxiety (i.e., self-rated feelings of anxiousness), physiological arousal, responses to mood adjectives (e.g., frightened, anxious, nauseous), and ratings of concern or worry”, we next examined respondents’ anxiety during the storm. Results show that only a small percentage of respondents reported that they “...lost sleep worrying about the storm” ($n=164$, 28%) or that they were “...worried, stressed out, or anxious about the storm” ($n=213$, 37%). Women were more likely to report anxiety and lost sleep than men ($p = 0.01$), while younger respondents (aged 18 to 39) were more likely to have lost sleep than older respondents ($p = 0.05$). In terms of household income, those making \$59,999 or less generally agreed that they were worried, stressed out, or anxious about the storm, while those with higher household incomes (\$60,000 or greater) generally disagreed ($p = 0.05$). In terms of racial identity, white respondents were less likely to be worried, stressed out, or anxious during the storm, while BIPOC respondents were more likely ($p = 0.05$).

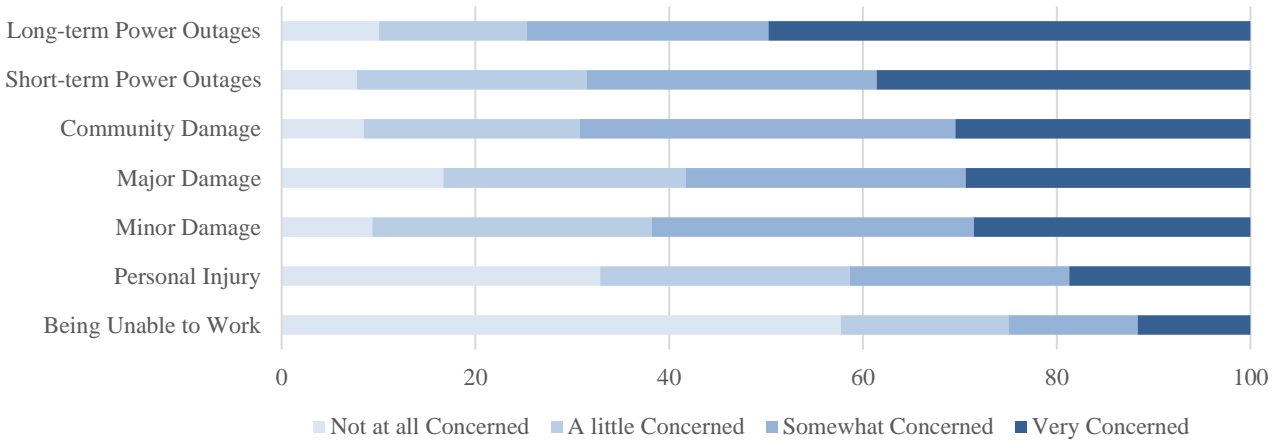


Figure 2: Concern by Potential Impacts

Efficacy Appraisal

Next, we wanted to gauge respondents' perceptions of self-efficacy (Figure 4). In general, most respondents agreed or strongly agreed that they knew they "...could do whatever was necessary to protect myself or my family from the storm" ($n = 417$, 72%), while approximately half of respondents agreed or strongly agreed that they knew they "...could handle whatever Hurricane Fiona threw at me" ($n = 256$, 45%). Only a small percentage of respondents disagreed or strongly disagreed with these statements (7% and 19%, respectively). In terms of socio-demographics, women were more likely to disagree with the statement that they could do whatever was necessary to protect themselves and their families than men ($p = 0.05$). Finally, the results demonstrate an inverse relationship between anxiety and self-efficacy. Respondents who reported they were anxious or lost sleep worrying about the storm were more likely to disagree that they could do whatever was necessary to protect themselves and their families ($p = 0.05$), or that they could handle whatever Hurricane Fiona threw at them ($p = 0.01$).

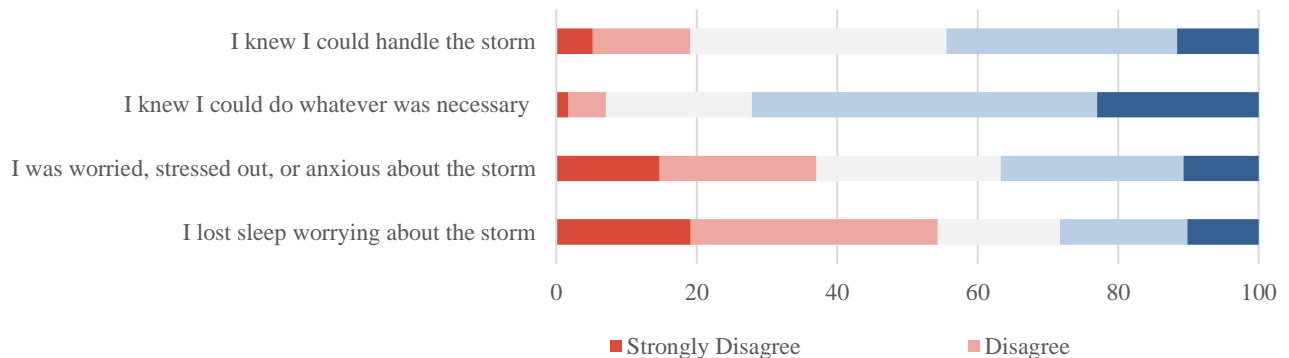


Figure 4: Perceptions of Self-Efficacy and Anxiety to the Storm

Fear-control processes

We next asked respondents three questions related to information seeking (avoidance) behaviors ("I wanted to know everything there was to know about the storm", "I spent a lot of time talking about the storm, either online or offline", and "I spent a lot of time searching for information about the storm"). By definition, if someone is searching out information about a potential threat, either by themselves or through conversations with others, then they are not engaging in avoidance behaviors. Several interesting results emerge from this analysis. Firstly, anxious searchers (i.e., high anxiety, high info-seeking) and disinterested respondents (low anxiety, low info-seeking) were more common than expected, while anxious-avoidant (high anxiety, low info-seeking) and pragmatic respondents (low anxiety, high info-seeking) were less common than expected ($p = 0.001$). However, anxious-avoidant behaviors were more common when anxiety was severe enough to disrupt one's sleep. Lastly, pragmatic respondents (i.e., those with low levels of anxiety who nevertheless engaged in information searching behaviors) represented only a small portion of the sample.

Danger-control processes

Protective actions

The Extended Parallel Process Model (EPPM) predicts that when threat appraisal and efficacy appraisal are high, then people will engage in danger control processes (i.e., problem-focused coping). In contrast, when threat appraisal is high but and efficacy appraisal is low, then people will engage in fear control processes (e.g., emotion-focused coping). To examine whether or to what extent this was true in the context of Hurricane Fiona, we first asked respondents what actions they took to prepare for the storm (Figure 5). Twelve different items were asked of respondents to ascertain the protective actions they did (not) engage in in advance of the hurricane (i.e., danger control processes). Almost all respondents (91.84%) indicated they took some form of preparedness action prior to the storm's arrival. The most common actions taken were purchasing necessities such as food, water, and/or medication (n=430), bringing in or tying down patio furniture and other outdoor items (n=415), charging electronics (n=381), purchasing snacks n=286), purchasing additional necessities (n=278), and purchasing gasoline (n=245).

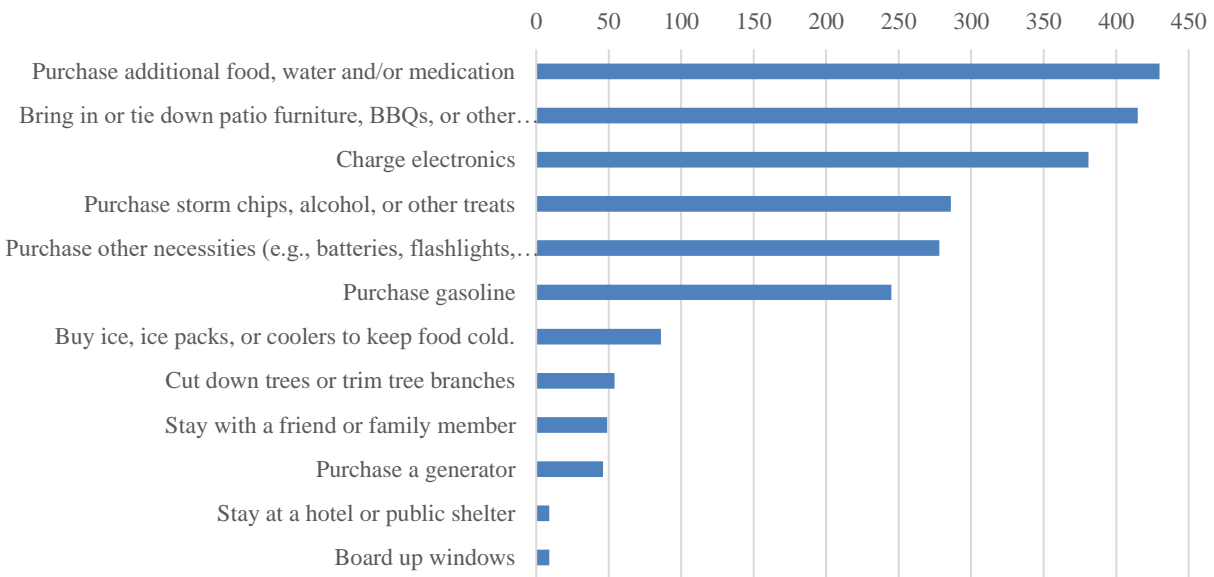


Figure 5: Preparedness Actions Taken Before Hurricane Fiona (select all that apply)

Next, we return to the previously introduced protective action latent classes. Figure 6 provides the item conditional percentages for each of the two latent classes. These effectively describe and define the two latent classes – Latent Class 1 (LC1) being a “low” protective action class, and Latent Class 2 (LC2) being a “high” protective action class. Clearly, each protective action was more likely to have been engaged in by those from LC2 as opposed to those from LC1. However, two other findings emerge from Figure 6: first, not all protective actions were equally likely to have been engaged in; and second, the relative gap in protective actions between LC1 and LC2 is not universal. For example, very few individuals from either Class relocated to a hotel/public shelter or boarded up windows. Cutting down trees or trimming tree branches was also a relatively infrequent protective action, but it was engaged in similarly between LC1 and LC2. The gap between the classes was also relatively smaller for bringing in or tying down outdoor items. However, in other actions, the disparity between the two classes was significant. For example, members of LC2 were far more likely to purchase food, water, or medicine; purchase other necessities; purchase snacks; or charge electronics. Additionally, those in LC1 had a 0% chance of acquiring ice, ice packs, or coolers to keep food cold compared with a 21.3% chance from Class 2. So, to summarize, LC2 represents those who engaged in a more diverse range of protective actions, while LC1 represents those who engaged in some immediate preparatory actions, particularly outdoors.

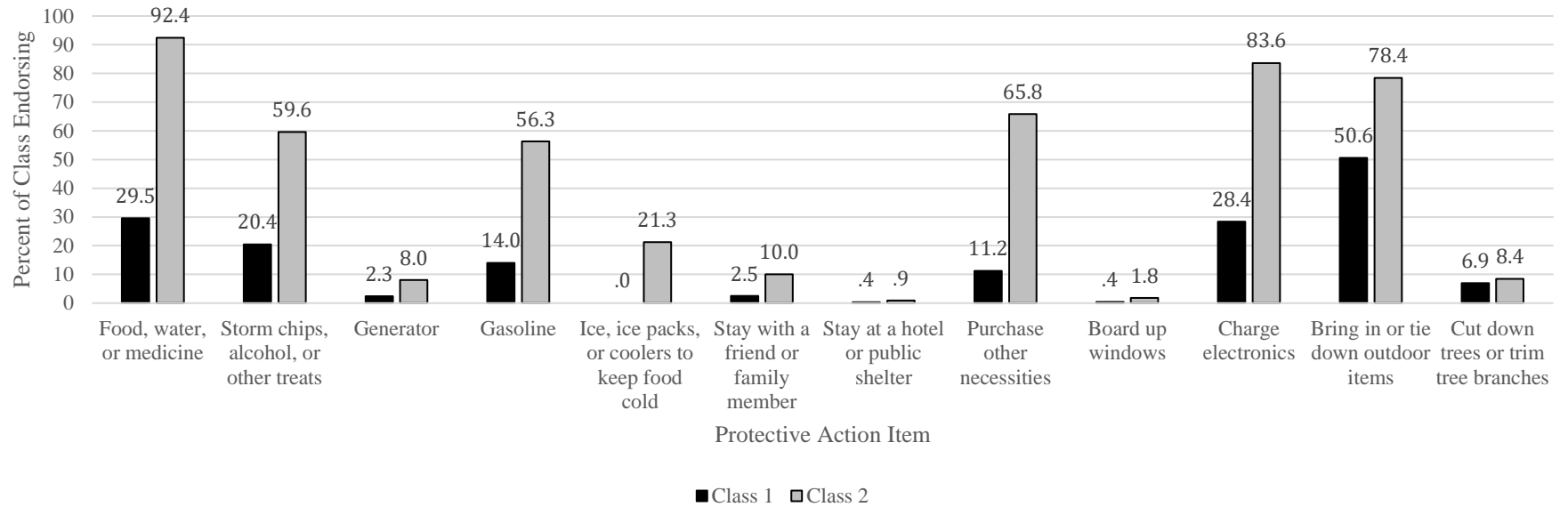


Figure 6. Protective Action Conditional Percentages by Latent Class

NOTES: Item conditional percentages by latent class are graphed above. The numbers above the bars indicate the specific percentage of those in the latent class that endorsed the specific protective action item.

Before linking the protective action classes to our cognitive and emotive factors, we first compare demographic characteristics for those assigned to each latent class. Table 3 shows these descriptive statistics for each of the two latent classes along with χ^2 tests of independence for whether there is (not) a statistically significant relationship between the listed demographic characteristic and latent class membership. The income distributions are fairly similar for the two latent classes, suggesting that protective action classes are not dependent upon one's financial resources. Similarly, there was no statistically significant variation in protective action class membership by age, but there is a descriptive caveat to that result. Namely, there seems to be a break occurring at age 40 where those under age 40 are more likely to belong to LC2 (the higher protective action class). Indeed, 30% of those in LC2 were under the age of 40 while only 20% of those in LC1 were under the age of 40. If we were to dichotomize age at 40, then we would find a statistically significant relationship between age and latent class membership, but such a dichotomization is not theoretically justified. Last, there are theoretically expected gender differences where women are more likely to belong to the higher protective action class than men are ($p=.001$).

Table 3. Demographics by Latent Class Membership with Chi-Square Tests of Independence

	Class 1 (Less Protective)		Class 2 (More Protective)		$\chi^2(df)$	p-value
	Count	Percent	Count	Percent		
Gender					11.37 (1)	.001
Male	134	60.1	153	45.54		
Female	89	39.9	183	54.46		
Age Group					7.22 (5)	.205
18-29	17	7.3	37	10.76		
30-39	32	13.8	69	20.06		
40-49	38	16.4	49	14.24		
50-59	46	19.8	67	19.48		
60 to 69	53	22.8	63	18.31		
70 years or older	46	19.8	59	17.15		
Household Income					3.25 (7)	.861
Less than \$20,000	27	12.0	28	8.3		
\$20,000 to \$39,999	44	19.5	68	20.1		
\$40,000 to \$59,999	43	19.0	74	21.9		
\$60,000 to \$79,999	33	14.6	52	15.4		
\$80,000 to \$99,999	24	10.6	37	11.0		
\$100,000 to \$119,999	15	6.6	26	7.7		
\$120,000 to \$139,999	14	6.2	21	6.2		
\$140,000 or more	26	11.5	32	9.5		

NOTES: Above table provides stratified demographic characteristics for each of the two protective action latent classes. The provided chi-square statistic and associated p-value are testing the null hypothesis of latent class being independent of the respective demographic characteristic.

Relationship between threat appraisal, efficacy appraisal, and protective action class

Next, we are interested in understanding whether and how threat appraisal and efficacy appraisal influence membership in LC1 or LC2. In preparation for linking these scales to the protective action latent classes, we first sum the items in each respective factor to produce what are effectively summated rating scales given the constant rating system within each factor. The anxiety sum is the sum of two items with a new minimum of 2 and a maximum of 10. The information seeking sum is the sum of three items with a new minimum of 3 and a maximum of 15. The self-efficacy sum is the sum of two items with a new minimum of 2 and a maximum of 10. The threat appraisal sum is the sum of four items with a new minimum of 4 and a maximum of 16.

Last, we run OLS regression models on latent class membership in what are equivalent to linear probability models on the dichotomous dependent variable where 0: LC1 member; 1: LC2 Member (Table 4). We retain the linear probability model instead of logistic regression for easier interpretation, but the results are consistent across model specifications. Column 1 of Table 4 regresses the anxiety, information seeking, and self-efficacy sums on protective action class membership. The EPPM predicts that HTA/HEA means that individuals will engage in danger control processes (i.e., preparedness and response), whereas HTA/LEA means that individuals will engage in fear control processes (i.e., denial, avoidance). However, the results demonstrate that efficacy has no influence

on latent action class, either by itself or in tandem with other variables. Put another way, efficacy appraisal does not affect whether or what actions respondents took during the storm. This result was surprising as it seemingly contradicts the existing literature. The relationship between threat appraisal and protective action class membership (i.e., behavioral change) was more complicated. First, when considered in isolation, threat appraisal is shown to affect protective action class membership with HTA being associated with LC2 and LTA being associated with LC1. However, when you include anxiety and information seeking, a slightly different pattern emerges. First, anxiety is predictive of protective action class membership for those with both low and high threat appraisals whereby anxious respondents belong to LC2 and less anxious respondents belong to LC1. In contrast, information seeking was only predictive of protective action class membership for those with low threat appraisals. In other words, respondents who expressed minimal concern about the storm and its hazards only engaged in varied protective behaviors if they also sought out information about the storm. This result underscores the potentially significant effect that official and unofficial information can have on behavior even when risk perception is low.

Table 4. Linear Probability Model Predicting Latent Class Group Membership

Regressor	Full Sample (1)	Low Threat Appraisal (2)	High Threat Appraisal (3)
Anxiety Sum	.048*** (.010)	.056*** (.016)	.041** (.013)
Information Seeking Sum	.030*** (.009)	.048*** (.013)	.009 (.012)
Self-Efficacy Sum	.006 (.013)	.015 (.020)	.002 (.017)
Constant	-.014 (.127)	-.293 (.189)	.282 (.181)
Sample Size	562	290	272

NOTES: The above models present the results of OLS regression analyses on the dichotomous dependent variable of latent class membership (coded as 0: Class 1 with lower protective actions; 1: Class 2 with higher protective actions). The .048 coefficient on anxiety sum imparts that for each one unit increase in the anxiety sum, the probability of belonging to Class 2 (as opposed to Class 1) increases by .048 on average while holding all else constant. *** $p < .001$; ** $p < .01$; * $p < .05$

DISCUSSION

Hurricane Fiona received considerable attention in the days leading up to its landfall in Atlantic Canada. The storm was heralded by news media and forecasters alike as a “once-in-a-lifetime”, “historic”, “deadly”, and “fearsome” storm. Accordingly, this event provided the opportunity to examine the interplay between threat appraisal, anxiety, efficacy appraisal, and information seeking (avoidance) to better understand how Atlantic Canadians responded to a record-breaking storm.

The first research question asked how Hurricane Fiona was perceived by respondents. In terms of related hazards, respondents were primarily concerned by high winds and rainfall; there was much less concern expressed about flooding and storm surge. This was unsurprising given that past damages from notable hurricanes often resulted from winds and rain (e.g., Hurricane Juan (2003), Hurricane Igor (2010), Hurricane Dorian (2019)). In terms of potential impacts, respondents were most concerned about power outages, damage in the community, and damage to personal property. They were much less concerned about personal injury or being unable to work.

Next, we asked whether respondents generally displayed high or low levels of self-efficacy and anxiety during the storm. The results demonstrate that respondents displayed relatively high levels of self-efficacy with men reporting higher levels of self-efficacy than women. Respondents also displayed relatively low levels of anxiety with gender (female), lower household income, and BIPOC racial identity being predictors of anxiety. Unsurprisingly, anxiety and self-efficacy were found to be inversely related – in other words, respondents who displayed high levels of anxiety often displayed lower levels of self-efficacy, and vice versa.

The last research question investigated the relationship between threat appraisal, efficacy appraisal, and behavioral change. The majority of respondents took some form of action in preparation for the storm, including purchasing necessities and emergency supplies, as well as taking actions to secure their homes. Latent class analysis revealed a two-class protective action framework: “low” protective action takers and “high” protective action takers. The

relationship between threat appraisal, efficacy appraisal, and membership in protective action class was more complicated than originally expected. Firstly, high threat appraisal was found to coincide with membership in LC2 (high action) when considered in isolation. However, when threat appraisal was considered in tandem with anxiety and information seeking, the pattern changed somewhat. More specifically, high anxiety is associated with membership in LC2 regardless of threat appraisal (high/low). Information seeking, in contrast, is only associated with membership in LC2 for respondents with low threat appraisal. In other words, when a person was unconcerned about the storm, they were unlikely to take varied protective action unless they were also seeking out and consuming storm-related information. This finding is both surprising and significant as it demonstrates the potentially positive and significant influence that information seeking can have on preparedness and response even when risk perception is low. Lastly, self-efficacy was not found to influence protective action class, whether considered in isolation or in tandem with other variables.

Taken together, the results demonstrate that most respondents perceived the storm to be a serious threat while also displaying generally high levels of self-efficacy and low levels of anxiety. Although this result might be surprising, given the historic nature of the storm and its widespread media coverage in the days leading up to landfall, many Atlantic Canadians take enormous pride in their ability to ‘weather the weather’. Still, a small portion of respondents displayed both high levels of anxiety and low levels of self-efficacy. While some of these respondents engaged in information seeking behaviors, ostensibly to reduce their anxiety levels, others seemed to avoid information about the storm altogether. Clearly, this kind of avoidance could have profound implications for all lifecycle phases of the emergency management cycle (e.g., preparedness, response, recovery, mitigation), particularly as the information being avoided could include details about storm conditions, potential impacts, and recommended protective actions. This finding, in tandem with the above finding that shows a positive relationship between information seeking and protective action class, underscores the importance of ‘casting a wide net’ when communicating with the public about coastal storms.

The results of this study seem to contradict the Extended Parallel Process Model (Witte 1992), which predicts that HTA/HEA results in problem-control processes (i.e., problem-focused coping), while HTA/LEA results in fear-control processes (i.e., emotion-focused coping). Almost all the respondents in our study took some form of preparedness action regardless of their efficacy beliefs – a fact that was even true for those respondents with high anxiety / low self-efficacy who engaged in avoidance behaviors. In other words, avoidance behaviors were rare, and when they did occur, they were undertaken *in tandem* with danger control processes. There are two possible explanations for this unexpected finding. Firstly, we asked two anxiety-related questions using a five-point Likert Scale (strongly disagree to strongly agree), rather than asking respondents to rank their anxiety. It is possible that this question design provided only limited insight into the ways anxiety interacted with risk perception and self-efficacy. Secondly, although “fear” in the context of the EPPM has been operationalized as anxiety and ratings of concerns or worry (e.g., Witte 1992), fear and anxiety are two distinct concepts. Specifically, anxiety refers to worry about a *potential threat* (i.e., future tense), whereas fear refers to worry about an *imminent or occurring threat* (i.e., present tense). It is possible that the EPPM, a fear-appeals model, does not fully capture the ways anxiety intersects with threat appraisal and efficacy appraisal during the preparedness phase of a disaster (i.e., when the threat is *possible*, but the exact nature, timing, or personal relevance of the threat is still uncertain). Thus, additional research is needed to further elucidate the ways anxiety *versus* fear intersect with threat appraisal, efficacy appraisal, and behavioral change during weather-related disasters. This research may benefit from comparing the EPPM (Witte, 1992) and the PADM (Lindell and Perry, 2012) to determine which model provides richer insight into the relationship between these variables, especially during the early phase of disaster.

Study limitations

The questionnaire instrument was disseminated by Qualtrics, an online survey provider, to panel participants who were living in the study region during the storm. Our sample is therefore limited to those who had access to the Internet, either through a smartphone or a desktop computer, and hence, the views, experiences, and opinions expressed by respondents may not be reflective of all Atlantic Canadians. Additionally, perceived efficacy (i.e., efficacy appraisal) as operationalized in this study was more reflective of self-efficacy than response efficacy. Future research would benefit from examining each of these efficacy components, both individually and in tandem, to better understand the role that efficacy may play in behavioral change.

Data Availability Statement

Both the anonymized dataset and the full questionnaire instrument are available from the corresponding author upon request. The results of the logistical regression are also available.

Conflict of Interest Statement:

The authors have no conflict of interest to report.

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