Received: 21 October 2022 | Revised: 25 January 2023 | Accepted: 17 March 2023

DOI: 10.1111/jfr3.12906

ORIGINAL ARTICLE

CIWEM Chartered Institution of Water and Environmental Management | Journal of Flood Risk Management | WILEY

Using the theory of planned behavior to identify key beliefs underlying flood-related adaptive behaviors in the province of Québec, Canada

Johann Jacob[1] | **Pierre Valois**[1] | **Maxime Tessier**[1] | **Denis Talbot**[2] | **François Anctil**[3] | **Geneviève Cloutier**[4] | **Jean-Sébastien Renaud**[2]

[1]Faculty of Education, Université Laval, 2320, allée des Bibliothèques, Quebec City, Quebec, Canada, G1V 0A6

[2]Faculty of Medicine, Université Laval, 1050, avenue de la Médecine, Quebec City, Quebec, Canada, G1V 0A6

[3]Water Research Centre, Department of Civil and Water Engineering, Université Laval, 1065, avenue de la Médecine, Quebec City, Quebec, Canada, G1V 0A6

[4]Faculté d'aménagement, d'architecture, d'art et de design, Université Laval, 2325, allée des Bibliothèques, Quebec City, Quebec, Canada, G1V 0A6

Correspondence
Johann Jacob, Faculty of Education, Université Laval, 2320, allée des Bibliothèques, Quebec City, QC, Canada, G1V 0A6.
Email: johann.jacob@fse.ulaval.ca

Funding information
Institut National de Santé Publique du Québec, Grant/Award Number: 2013-2020 Climate Change Action Plan (PACC 2013-2020)

Abstract

Given that flooding episodes are occurring at a greater rate due to climate change, individuals must adopt certain adaptation behaviors to prevent or mitigate the anticipated or negative impact of such events. However, few studies have assessed if and how households and individuals have actually taken action in this regard. Because some individual beliefs can be linked to facilitating factors and barriers to action, a better understanding of the adoption of adaptive behaviors requires a combined analysis of individual psychosocial factors. The purpose of this study was to develop a better understanding of the reasons underlying the adoption of behaviors related to structural adaptation to flooding by people living in or near flood-prone areas in the Province of Québec (Canada). Results of a series of structural equation modeling showed that behavioral, normative and control beliefs were all significant predictors of the respondents' intention to adopt structural flood protective behaviors, with normative beliefs being the strongest. By identifying the best psychosocial predictors of the adoption of such behaviors, the results of this study provide valuable insights regarding the most effective factors to be used in public health messages to promote the adoption of behaviors related to structural adaptation to flooding.

KEYWORDS

adaptation, beliefs, climate change, flooding, theory of planned behavior

1 | INTRODUCTION

Flood events are a growing concern worldwide, becoming more frequent and severe as a result of infrastructure development and climate change (Hirabayashi et al., 2013; Kundzewicz et al., 2014; Milly et al., 2002). Natural disasters such as flooding are the most common in Canada and are also the most expensive, with financial impact growing rapidly (Natural Resources Canada, 2017). From 1983 through 2008, Canadian insurance losses averaged CAN $405 million per year, whereas those losses rose to CAN1.8 billion per year for the period from 2009 to 2013 (Moudrak et al., 2015). Recent spring floods in Fort McMurray, in the Province of Alberta caused more than

CAN$520 million in damage (Malbeuf, 2020). Similarly, in the Province of Québec, floods caused damage worth more than CAN$2 billion over the course of the 20th century. The series of flash floods in the Saguenay region in 1996 itself caused around CAN$1 billion in damage (Buttle et al., 2016). Important flooding also occurred in the springs of 2017 and 2019. In 2017, the damage caused by floods to southern Quebec municipalities was estimated at more than CAN$376 million, while affecting 293 municipalities in 15 regions, flooding approximately 5400 residences and forcing the evacuation of more than 4000 people as well as the closure of several roads (MAMH, 2020). As for the spring floods of 2019, they affected more than 250 Quebec municipalities (Saint-Arnaud, 2019), once again flooding thousands of homes, forcing the evacuation of more than 10,000 people and causing the closure of several roads. In the province of Quebec, flooding can affect 80% of municipalities located along a river (Natural Resources Canada, 2006).

Additionally, the potential impacts of flooding on physical and mental health are numerous (Zhong et al., 2018; Jermacane et al., 2018; Fernandez et al., 2015). For instance, a total of 18 deaths were reported during the 22 major flooding events that occurred in Canada between 2000 and 2015 (Guha-Sapir et al., 2015), on top of multiple injuries, diseases and mental health issues. The results of a large-scale survey carried out in certain regions of the province of Quebec highlighted that, almost a year after the floods, the people who were flooded and those who were disturbed by the floods were significantly more likely to have mental health problems (post-traumatic stress, psychological distress, an anxiety disorder such as a phobia, obsessive compulsive disorder or panic disorder, or a mood disorder such as depression, bipolarity, mania or dysthymia) than those who were not exposed to flooding (Généreux et al., 2020).

Adaptation in human systems refers to "the process of adjustment to actual or expected climate and its effects, in order to moderate harm or exploit beneficial opportunities" (IPCC, 2022). Regarding floods, adaptation encompasses "reactive or proactive actions that individuals can take, alone or with others, to respond to the impacts of climate change, and to protect or benefit themselves, others, and/or the environment in the short and long term" (Carman & Zint, 2020, p. 10). In this view, actions or behaviors to adapt to floods "refer to actions that aim at preventing or minimizing anticipated or negative consequences of flood events. Such actions can be taken before, during or after an event" (Kuhlicke et al., 2020, p. 3) and are self-initiated household actions, in order "to avoid the direct physical and financial impacts imposed by climate-exacerbated hazards" (Wilson et al., 2020, p. 200). Numerous typologies of behavior that people can adopt in anticipation of a flood have been proposed (e.g., Dillenardt et al., 2022; Noll et al., 2022; van Valkengoed et al., 2022). One of these typologies, which distinguishes between structural measures (i.e., what is done on a house or land, such as waterproofing foundations) and nonstructural measures (i.e., what does not affect the house itself, such as drawing up an inventory of personal property) was used in several studies (e.g., Mondal et al., 2021; Noll et al., 2022; Oubennaceur et al., 2022; Valois et al., 2019; Valois, Bouchard, Talbot, et al., 2020). However, few studies have assessed if and how households and individuals adopt and implement structural adaptation measures and behaviors while also aiming to identify the key psychosocial determinants of their adoption (Babcicky & Seebauer, 2019; Grothmann & Reusswig, 2006; Valois et al., 2019; Valois, Tessier, Bouchard, et al., 2020). The current study focuses specifically on this second element.

Monitoring of flood adaptation in the Province of Québec (Canada) began in 2015, namely with a study (Valois et al., 2019) conducted on Quebeckers living in or near a flood-prone area. This led to the development and the validation of five indices of adaptation to flooding according to the chronology of flood events: (a) pre-alert preventive behaviors, (b) post-alert behaviors, (c) behaviors during a flood not requiring evacuation, (d) behaviors during a flood requiring evacuation, and (e) post-flood behaviors. The same five indices were used in a subsequent study conducted in 2019 and 2020, which focused on the development of adaptation to flooding in the province over time (Valois, Tessier, Bouchard, et al., 2020). Although monitoring flood adaptation allows decision makers to better understand Quebeckers' susceptibility to flood events, it does not per se provide insights into how to improve the current situation and increase rates of adoption of adaptive behaviors. To better understand what motivates people to protect themselves and their homes from floods, research needs to be conducted on people's beliefs regarding flood adaptation-related behaviors (Clayton et al., 2015; Gifford et al., 2011; Swim et al., 2011; Valois, Talbot, Bouchard, et al., 2020). While it appears essential to monitor and evaluate progress in terms of adaptation, there is also a need to capture, in the monitoring and evaluation (M&E) of adaptation, the complexity of the process of adopting an adaptation response and further explore the psychosocial dimensions inherent in the adjustments or changes in behavior implied by adaptation.

The need to better understand the psychosocial processes by which adaptation occurs has led some authors to emphasize the importance of an individual perspective to adaptation (Carman & Zint, 2020; Meinel & Höferl, 2017) and autonomous behavioral adaptation

(Kuhlicke et al., 2020; Wilson et al., 2020). Moreover, there is abundant literature showing that psychosocial factors or determinants like assessment of climate-related risks and impact, perceived adaptation efficacy and perceived self-efficacy (Clayton et al., 2015; Gifford et al., 2011; Grothmann & Patt, 2005) can influence an individual's motivation to adopt certain behaviors to protect themselves from the impact of a climate hazard. Conversely, low motivation to adapt or negative beliefs about adaptation are among the most important barriers to action (Grothmann et al., 2013). Because some individual beliefs can be linked to facilitating factors and barriers to action, a better understanding of the adoption of adaptive behaviors requires a combined analysis of these types of factors at the individual level (Meinel & Höferl, 2017).

In this regard, Ajzen et al. (2011) revealed how changing people's behaviors and lifestyles is more demanding than simply conveying information on a subject matter. A large number of factors, including psychological barriers, beliefs, personal values, political views, biases, attitudes towards a particular behavior and goals can limit change (Albright & Crow, 2015; Gifford, 2011; Gifford & Nilsson, 2014; Sterling, 2011; Stern, 2011; Yazar et al., 2021; Zografos et al., 2016). Various models have been used in attempts to identify what motivates people to change their behaviors, such as the Protection Motivation Theory (Rogers, 1983), the Protection Action Decision Model (Terpstra & Lindell, 2013), the Model of Private Proactive Adaptation to Climate Change (Grothmann & Patt, 2005) and the Health Beliefs model (Rosenstock, 1974).

Developed from the field of social psychology, the Theory of Planned Behavior (TPB) (Fishbein & Ajzen, 2010) is another model that has been frequently and successfully used in the past (de Leeuw et al., 2015; Deng et al., 2017; Oreg & Katz-Gerro, 2006; Valois, Bouchard, Aenishaenslin, et al., 2020; Valois, Talbot, Bouchard, et al., 2020; Zhang et al., 2020) to describe the psychological processes of people who must adopt new behaviors in order to adapt to climate change or make pro-environmental choices. Multiple meta-analyses [see, for instance, Steinmetz et al., 2016, Bamberg & Möser, 2007, Hines et al., 1987 and Klöckner, 2013] have also demonstrated the strength of the TPB in explaining decision-making and crafting targeted behavior change interventions. As such, this social-cognitive model of human behavior can be successfully used to identify the beliefs that underlie people's willingness to adopt flood adaptation-related behaviors.

2 | THEORY OF PLANNED BEHAVIOR—TPB

The TPB is a theory of social psychology that is commonly used to explain human behavior (Ajzen, 1991; Wang et al., 2019; Zoellner et al., 2017). According to this theory, the decision to adopt a behavior is determined by the salient beliefs an individual have about adopting said behavior (see Figure 1).

More specifically, three broad classes of beliefs are distinguished: behavioral beliefs, normative beliefs and control beliefs. Behavioral beliefs are operationalized by measuring a person's beliefs about the likely outcomes of performing a particular behavior (outcome expectancies) weighted by the assessment of such outcomes (Fishbein & Ajzen, 2010, p. 18). It could refer to, for example, an advantage or a disadvantage of performing the behavior in question (e.g., making the structure of a dwelling more water-resistant would help maintain its value). Normative beliefs are based on individual perceptions of what important referents (e.g., family members,

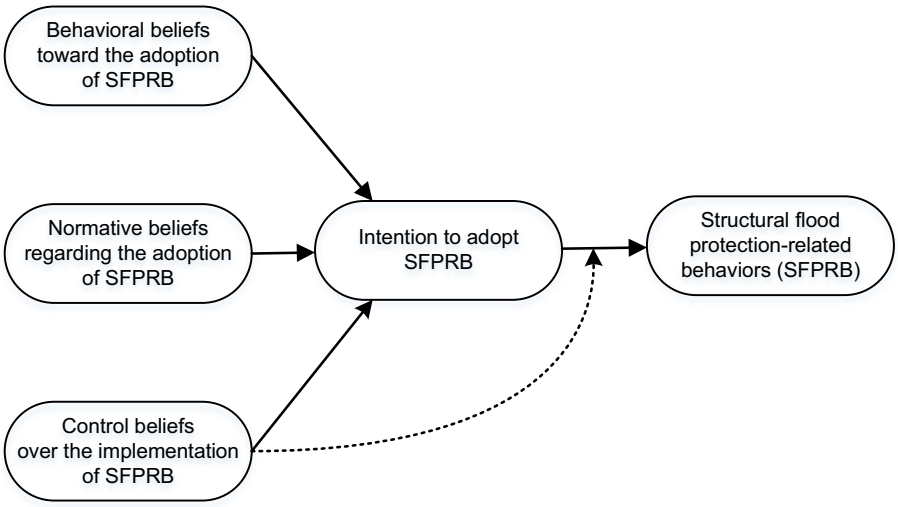

FIGURE 1 The theory of planned behavior.

neighbors, government representatives) think they (the individuals) should do weighted by their motivation to comply with these referents. Finally, a control belief is defined as a person's subjective probability that a given facilitating factor will be present in the situation of interest, weighted with the factor's perceived power to facilitate performance of the behavior (Ajzen & Kruglanski, 2019). Financial help to improve the structure of a dwelling would be an example of a factor that may interfere with or facilitate performance of the behavior. The TPB also postulates that this perceived control, if it accurately reflects actual control, can moderate the effect of intention on behavior (see the dotted arrow in Figure 1). Intention should have a stronger effect on behavior when actual control is high rather than low. People are more likely to act according to their intentions when they really have control over the adoption of the behavior (Fishbein & Ajzen, 2010).

The purpose of this article was to develop a better understanding of the beliefs underlying the adoption of behaviors related to structural adaptation to flooding by people living in flood-prone areas in the Province of Québec (Canada). For that purpose, this study uses as dependent variable a validated pre-flood prevention-related behaviors index developed by Valois et al. (2019) and the key determining beliefs in people's motivation to adopt behaviors related to structural adaptation to flooding identified in a qualitative pilot study conducted in 2016 (Valois et al., 2017). To the best of our knowledge, no study aiming to identify the key psychosocial determinants of the adoption of behaviors related to structural adaptation to flooding used a validated measure of households and individuals adaptation actions as dependent variable. By allowing the identification of the key beliefs as psychosocial predictors of the adoption of behaviors aimed at making the structure of people's homes more water-resistant, the results of this study provide valuable insights regarding the most effective factors to be used in public health messages to promote the adoption of such behaviors.

3 | MATERIALS AND METHODS

3.1 | Preliminary study

Following Ajzen (1991), we conducted a pilot study before finalizing the questionnaire, with the goal to identify the key determining beliefs in people's motivation to adopt behaviors related to structural adaptation to flooding. The process broadened and validated the set of beliefs included in the main study. This preliminary study involved a total of 30 individuals randomly selected by a polling firm and who were surveyed in focus groups of five to eight individuals. We used an open-ended questionnaire to interview them regarding (a) the advantages and disadvantages of adopting various behaviors, (b) the individuals or groups of people who would approve or disapprove of the respondents performing these behaviors and (c) the factors that could facilitate or interfere with the adoption of these behaviors. Overall, the more frequently mentioned beliefs were selected and used to pinpoint the belief statements that would be investigated in the main survey. More details about the method used for the pilot study are provided in Valois et al. (2017).

3.2 | Main study

To identify the beliefs that influence the adoption of flood prevention-related behaviors in the Province of Québec (area of 1,667,441 km^2; population of 8.3 million people), a population-based study was conducted in 2019 using a cross-sectional design. The target population was identified according to the flood-prone areas designated by the Centre d'expertise hydrique du Québec (Quebec Water Expertise Center). We then selected households with their main residences located in or near a flood-prone area, resulting in a target population of 136,476 households.

We used a stratified sample to reflect the geographical distribution by administrative region of the population in the flood-prone areas across the Province of Québec. A polling firm conducted a telephone survey with the respondents, targeting people who were 18 years old or over, who could speak either French or English and whose primary residence was either in a flood-prone area or within 150 m of a flood-prone area. Each interview lasted 30 min on average, with a response rate of 24.5% ($n = 951$). However, given the aim of our study, respondents also had to be homeowners, since renters would not be able to perform most of the behaviors. For this reason, renters ($n = 188$) were removed from the initial sample. The final sample included 763 homeowners, with 194 living within 150 m of a designated flood-prone area and 569 individuals living in a flood-prone area. The data were reweighted to keep the same proportion for each administrative region in the sample as in the target population (Deville & Särndal, 1992). Regions with fewer respondents in the final sample than in the quotas received higher weights to achieve a total regional weight equal to the quotas for each region.

Among the respondents, there were 331 men (43.4%) and 432 women (56.6%); the majority were in the 60–64 year old group (14.0%). Most respondents had a university degree (37.6%) and an annual household income

above CAN$100,000 (20.8%). See Valois et al. (2019) for a more detailed description of the data collection strategy and Table 1 for more details about the characteristics of the sample.

The questionnaire administered assessed the constructs of the TPB: the structural flood protection-related behaviors (Valois et al., 2019), the respondents' intention to adopt these behaviors and their behavioral beliefs,

TABLE 1 Survey sample characteristics.

Variables		Frequency	Percent
Age	25–29	8	1.05
	30–34	17	2.23
	35–39	41	5.37
	40–44	60	7.86
	45–49	59	7.73
	50–54	77	10.09
	55–59	103	13.50
	60–64	107	14.02
	65–69	106	13.89
	70–74	76	9.96
	75–79	54	7.08
	80–84	33	4.33
	85–89	9	1.18
	90+	3	0.39
	Refused to answer	10	1.31
Gender	Men	331	43.38
	Women	432	56.62
Household income (yearly, CAD$)	Under $10,000	7	0.92
	$10,000–$20,000	39	5.11
	$20,001–$30,000	58	7.60
	$30,001–$40,000	60	7.86
	$40,001–$50,000	54	7.08
	$50,001–$60,000	67	8.78
	$60,001–$70,000	58	7.60
	$70,001–$80,000	44	5.77
	$80,001–$90,000	34	4.46
	$90,001–$100,000	27	3.54
	Over $100,000	159	20.84
	Refused to answer	156	20.44
Education	Elementary school or less	14	1.83
	Secondary school (partial or complete)	206	26.99
	Postsecondary (general and vocational college, i.e., a 2-or 3-year step between high school and university)	248	32.51
	University degree	287	37.61
	Refused to answer	8	1.05
Location of primary residence	Within a flood-prone zone	569	74.57
	Within less than 150 m from a designated flood-prone area	194	25.43

normative beliefs and control beliefs towards the adoption of these behaviors. This questionnaire was pretested to verify its psychometric qualities ($n = 65$ respondents not included in the final sample). Using Item Response Theory (IRT) and other test theory analyses, we made sure that the question scales were appropriate and allowed discrimination across all levels for the latent trait measured. Latent constructs are used to quantify variables that are not measurable directly (e.g., beliefs). However, it is possible to estimate them through a statistical model including multiple variables that can be measured and are related to the latent construct.

3.3 | TPB constructs

Structural flood protection-related behaviors. We used the pre-flood prevention-related behaviors from the index developed by Valois et al. (2019) to measure adaptation to flood risks. This index was originally composed of 15 behaviors that were either structural or nonstructural. We differentiated structural behaviors, which consist of physical changes to a house or the land around the property from nonstructural behaviors, such as seeking information, owning a water pump, knowing how to cut off the water or electricity and making a list of belongings in case of flooding. Therefore, the adoption of pre-flood protection-related behaviors was measured using nine of the 15 behaviors from the original index that concern structural behaviors (See Table 2). Response options were yes, no, do not know and refusal. Item response theory analyses and classical test theory analyses indicated that the scale used to measure the structural flood protection-related behavior index was adequate: all items showed good discrimination across varying standardized levels of the trait measured and had option characteristic curves that showed good discrimination (see Valois et al., 2019), that is, each increasing option became more likely than the previous as the trait level increased.

TABLE 2 Component of the index of structural flood protection-related behavior.

Behavior	Frequency	Percent
Waterproof foundations	178	23.33
Raise foundations (including the installation of pilings)	62	8.13
Raise wall baseboard heaters and electrical outlets	133	17.43
Replace water-sensitive flooring (e.g., carpeting) with a waterproof finish (e.g., ceramic)	128	16.78
Install a backflow valve	328	42.99
Make other changes to the house	170	22.28
Redesign the landscape to help water runoff	164	21.49
Check to make sure that the foundation drain is not blocked	316	41.42
Make other changes to the property	76	9.96

Intention to adopt structural flood protection-related behaviors. This variable was measured with three questions on the respondents' intention to adopt these behaviors, their desire to do so and the likelihood of them doing so (Table 3). The measure had good internal consistency according to Cronbach's α.

Behavioral beliefs. Participants rated each of the behavioral beliefs in terms of its perceived likelihood and its subjective value (Table 3). According to an expectancy-value model (Fishbein & Ajzen, 2010), the perceived likelihood of each outcome was multiplied by its subjective value and the resulting products were summed.

Normative beliefs. Participants rated each of the normative beliefs in terms of its perceived subjective probability that important referents would expect them to perform the behavior and the motivation to comply to this expectation (Table 3). Then, perceived subjective expectation was multiplied by motivation to comply and the resulting products were summed (Ajzen & Fishbein, 1975).

Control beliefs. Participants rated each of the control beliefs in terms of its perceived subjective probability that a given facilitating factor will be present in the situation of interest and the factor's perceived power to facilitate performance of the behavior (Table 3). Then, perceived control belief was multiplied by the factor's perceived power and the resulting products were summed (Ajzen, 1985).

3.4 | Statistical analysis

We applied structural equation modeling (SEM) (Byrne, 2012) using Mplus Version 8 (Muthén & Muthén, 2017). Along with the linear mixed model/hierarchical linear model, SEM "is the most widely recognized statistical solution in the social sciences" (Tarka, 2018, p. 322). According to Novikova et al. (2013), SEM offers three main advantages over traditional multivariate techniques: (1) SEM explicitly assesses the measurement error, as it offers estimates of error variance parameters for independent and dependent variables (Byrne, 2012). (2) SEM allows the description of latent (unobserved) traits, that are estimated from multiple observed variables, as well as the relations among

TABLE 3 TPB constructs.

Constructs	Items	Response options	Cronbach's α
Intention	• Do you plan on adopting or continuing to adopt the adaptive measures or behaviors to improve the structure of your home to make it more water-resistant? • You want to adopt or to continue adopting adaptive measures or behaviors to improve the structure of your home to make it more water-resistant. • It is very likely that you'll adopt these adaptive measures and behaviors to improve the structure of your home to make it more water-resistant.	6-point scale: strongly disagree to strongly agree	0.83
Behavioral beliefs	Respondents rated the likelihood that adopting adaptive measures or behaviors to improve the structure of their home to make it more water-resistant would produce seven outcomes (expected outcomes) and then rated the importance of each outcome (evaluation of outcomes) • Reasonable expenses given the respondent's situation • Foolproof water damage protection for the respondent's home • Protection of the respondent's physical health • Protection of the respondent's psychological health • Maintenance of the value of the respondent's home • Feeling as though these investments were not made in vain • Too much inconvenience during the respondent's home renovations to make it more water-resistant	Expected outcomes 6-point scale: very unlikely to very likely Evaluation of outcomes 6-point scale: strongly disagree to strongly agree When necessary, scores from items that had an opposite effect on the dependent variables (e.g., too much inconvenience) were adjusted.	0.80
Normative beliefs	Participants indicated their perception of what important referents think they ought to do (perceived expectations) and their motivation to comply • The respondent's neighbors • The respondent's family (spouse, children) and friends • Municipality and government representatives • People the respondent know (neighbors or others living in another neighborhood or city) who have experienced flooding • Experts	Perceived expectations 6-point scale: strongly disagree to strongly agree Motivation to comply with important others' expectations 6-point scale: strongly disagree to strongly agree	0.89
Control beliefs	Participants rated the occurrence likelihood of each factor as well as its perceived facilitating value (i.e., it will be helpful). • The respondent would have or have had enough financial help to improve the structure of the home	Occurrence likelihood 6-point scale: strongly disagree to strongly agree Facilitating value 6-point scale: strongly disagree to strongly agree	0.73

(Continues)

TABLE 3 (Continued)

Constructs	Items	Response options	Cronbach's α
	• The steps that would be involved or that the respondent has done to improve the structure of his/her home are simple • The laws and regulations would be or were easy to understand to help the respondent improve the structure of his/her home • The respondent would have or have had access to easily understandable information to improve the structure of his/her home • The respondent does not have or did not have physical constraints limiting his/her ability to improve the structure of his/her home		

constructs. The psychometric properties of measures and the estimation of relations among constructs can be compensated for biases linked to random error and construct-irrelevant variance (Tomarken & Waller, 2005). (3) SEM can be used as a conceptual or theoretical structure or model to test fully developed models against available data. Unlike other procedures (e.g., multiple regression), SEM offers "measures of global fit that can provide a summary evaluation of even complex models that involve a large number of linear equations" (...) instead of "mini-tests of model components that are conducted on an equation-by-equation basis" (Tomarken & Waller, 2005, p. 34).

First, we tested the TPB model in which the behavioral, normative and control beliefs influence the adoption of structural flood protection-related behaviors through intention. Second, from this model, we tested the presence of a moderating effect of control beliefs on the influence of the intention to adopt adaptive behaviors (Ajzen, 2012). Finally, in order to gain a better understanding of the most important beliefs, we tested the TPB model using the individual beliefs to identify which one of them more strongly predicts intentions. Comparative fit index (CFI), Tucker-Lewis index (TLI) and Root mean square error of approximation (RMSEA) were used to evaluate the fit of the models. Acceptable model fit is indicated by CFI and TLI values equal to or greater than 0.90 and less than 0.95 and RMSEA values between 0.05 and 0.08. Excellent model fit is indicated by CFI and TLI values equal to or greater than 0.95 and RMSEA values equal to or less than 0.05 (Hu & Bentler, 1999; Kline, 2015). Testing the moderating effect of the control beliefs on the influence of intentions regarding the behavior adoption index requires the use of models with latent variable interactions. Adding interactions to the models within Mplus prevents the computing of fit statistics such as CFI, TLI, and RMSEA (Little et al., 2006).

4 | RESULTS

As a preliminary analysis, we evaluated the correlation between the items of each latent construct. The correlation between the behavioral belief that adopting the behaviors would protect respondents' physical health and the behavioral belief that adopting the behaviors would protect the respondents' psychological health was $r = 0.784$. This was high enough to cause fitting issues for the SEM model. Thus, these constructs were combined by using the highest score on either of these items. A similar issue was detected in the normative beliefs. The belief that "experts" thought the respondents should adopt the behaviors was strongly correlated with two other beliefs: (i) the belief that "municipalities and government representatives" thought the respondents should adopt the behavior ($r = 0.708$); ii) the belief that "people having experienced a flood whom the respondents knew" thought they should adopt the behaviors ($r = 0.624$). Thus, this item was omitted from the analysis.

Then, a series of SEM analysis was performed. First, we tested the TPB model that included the variable "structural flood protection-related behaviors," "intentions to adopt structural flood protection-related behaviors," and the underlying behavioral, normative and control beliefs (see Figure 2). The fit of this model to the data ranged from acceptable (CFI = 0.934, TLI = 0.926) to excellent (RMSEA = 0.039). Results show that the model accounted for 45.8% of the variance in the respondents' intentions to adopt structural flood protection-related behaviors and 20.2% of the variance in actual behavioral adoption. Results revealed that each category of underlying beliefs were significant predictors of the intentions, with normative beliefs being the strongest ($\gamma = 0.456$, SE = 0.038, $p < 0.01$), followed by behavioral beliefs ($\gamma = 0.254$, SE = 0.038, $p < 0.01$) and control beliefs ($\gamma = 0.233$, SE = 0.045, $p < 0.01$).

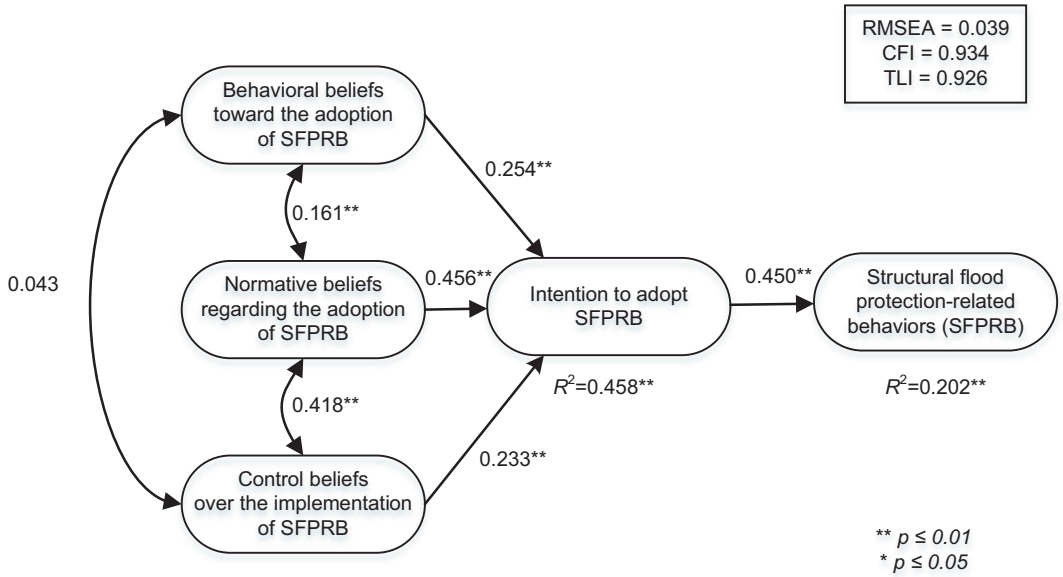

FIGURE 2 TPB variables predicting the implementation of structural flood protection-related behaviors.

As a second SEM analysis, we attempted to fit the same model with a moderating effect of the control beliefs over the effect of the intentions on the adoption of the behaviors. This moderating effect proved to be non-significant ($\gamma = 0.000$, SE $= 0.053$, p-value $= 0.996$). Thus, the model was not retained.

Finally, we performed another SEM for which each item from the underlying behavioral, normative and control beliefs directly predicted intentions. In other words, six behavioral beliefs (six expectancy-value products), four normative beliefs and five control beliefs were tested in predicting the respondents' intentions to adopt structural flood prevention-related behaviors. The 15 beliefs explained 45.2% of the variance in intention to adopt structural flood prevention-related behaviors, the model providing an excellent fit: CFI $= 1.00$; TLI $= 1.002$; RMSEA $= 0.00$. Two behavioral beliefs were significant predictors of intentions: "adopting the behaviors would protect the respondents' physical health and psychological health" ($\gamma = 0.097$, SE $= 0.041$, $p = 0.016$); "adopting the behaviors would help maintain the value of the respondents' home" ($\gamma = 0.126$, SE $= 0.043$, $p = 0.003$). Furthermore, two of the four normative beliefs were significant predictors of intentions, notably the belief that the respondents' family and friends would think that they should adopt the behaviors ($\gamma = 0.358$, SE $= 0.054$, $p = 0.001$) and the belief that the people the respondents knew who had experienced a flood would think that they should adopt the behaviors ($\gamma = 0.201$, SE $= 0.047$, $p = 0.001$). Finally, two out of the five facilitating factors were significantly related to intentions: the belief that the steps involved in improving the house structure would be simple ($\gamma = 0.176$, SE $= 0.042$, $p = 0.001$); the belief that not having any physical constraints to their ability to improve the house structure would influence their control over the adoption of the behaviors ($\gamma = 0.147$, SE $= 0.038$, $p = 0.001$).

5 | DISCUSSION

The main goal of this study was to use the TPB to identify the beliefs of people living in flood-prone areas that are the most strongly associated with the adoption of adaptive behaviors aimed at making the structure of people's homes more water-resistant. Results from the study allowed to clearly identify beliefs that are significantly related to people's decision-making when it comes to flood preparedness. Notably, our results suggest that all three categories of beliefs from the TPB had an impact on the respondents' intention to adopt structural flood protection-related behaviors, with normative beliefs being the most important determinant. Results also show that none of the prevention-related behaviors comprising the index were adopted by more than half of the respondents. These results are similar to those we obtained in a previous study (Valois, Tessier, Bouchard, et al., 2020).

Although the results highlight the need for a higher adaptation rate by the population at risk, they also confirm the potentiality of targeted interventions based on the individual beliefs significantly related to the respondents' intention to adopt behaviors to improve the structure of their homes. To be effective, an intervention should target and modify the behavior-relevant beliefs

that serve as determinants to adopting specific adaptation measures. This means that interventions aiming to foster the adoption of structural flood protection-related behaviors would be more effective if they were designed to reinforce supportive beliefs and counter negative ones (Fishbein & Ajzen, 2010, p. 332). Our results suggest that normative beliefs are the best determinants of the respondents' intention to adapt by improving the structure of their homes. Assessment of the key normative beliefs of Quebeckers living in flood-prone areas or within 150 m from a designated flood-prone area shows that the respondents who believed that "their family and friends would think they should adopt the behaviors" and that "the people they knew who had experienced a flood would think they should adopt the behaviors" are more likely to develop a positive intention to adopt adaptation behaviors and put such intention in action. Public communication strategies and policies would gain from emphasizing such influence. Therefore, public awareness messages featuring the testimonials of figures portraying neighbors, families and friends could be key in improving adaptation. Similar work based on the TPB has already proven effective in shaping people's beliefs and attitudes on speeding (Stead et al., 2005). Narratives with personal testimonials have also been used successfully for health campaigns against smoking (Kim et al., 2012). In this case, using personal testimonials from people most likely to influence other people's decisions (i.e., figures posing as friends and family or people who have experienced a flood) regarding structural behaviors could be helpful in crafting effective media campaigns.

Alongside normative beliefs, control and behavioral beliefs may influence individuals' intention to adopt structural flood protection-related behaviors. Literature pertaining to the Protection Motivation Theory shows that coping appraisal (i.e., a cognitive process by which a person evaluates various actions that may reduce a perceived threat) has a strong influence on flood mitigation behavior (Babcicky & Seebauer, 2019). Coping appraisal includes constructs like response efficacy, self-efficacy and response costs, which are somewhat included in control and behavioral beliefs in the TPB. Babcicky and Seebauer (2019) found that response efficacy (i.e., believing that an action will be effective in reducing damage expected from a threat) and response costs (i.e., the financial resources, time and effort to implement an action) were significant predictors of structural protection. This is partly in line with our results. Moreover, assessment of the key behavioral beliefs show that the respondents who believed that adopting structural flood protection-related behaviors would produce outcomes like "protecting their physical health and psychological health" and "helping to maintain the value of their home" were more likely to develop a positive intention to adopt adaptation behaviors and put this intention in action. Other studies (e.g., Grothmann & Reusswig, 2006; Terpstra & Lindell; 2013) had also shown that response efficacy was a good predictor of the intention to adopt actions to adapt to flooding. For instance, Terpstra and Lindell (2013) showed that flood hazard adjustments were significantly more likely to be adopted in the future by individuals who felt they would be more effective at protecting people and property and who thought they would be useful for other purposes than flood protection.

Our results also show that the belief that adopting structural flood protection-related behaviors involves reasonable expenses did not influence the intention to adopt. This is also similar to the results reported by Terpstra and Lindell (2013), which, contrary to their hypothesis, did not show a negative correlation between resource-related attributes like perceived cost and hazard adjustment adoption intentions. However, our result was slightly different from what was observed in our preliminary study (Valois et al., 2017), in which respondents identified financial constraints as a significant barrier to preventive adaptation and, at the same time, financial assistance as one of the most important facilitators. Results regarding control beliefs shed an interesting light regarding the role of cost in the intention to adopt, as efforts to adapt might not always involve financial resources. Indeed, the results show that the respondents who believed that "the steps that would be involved in improving the house structure would be simple" and that "not having any physical constraints to their ability to improve the house structure" are more likely to develop a positive intention to adopt adaptation-related behaviors and put their intention in action. This suggests that, in addition to promoting preventive behaviors and providing grants, incentives or tax credits to people living in flood-prone areas allowing them to implement some of these costly preventive measures, public outreach should also ensure that people living in flood-prone areas come to consider that the efforts required to adapt may not be as demanding or difficult as they initially thought. Offering personalized support, for example, could favor such considerations. This, however, raises the question as to who or what organization should be in charge of such support. In this respect, collective movements could play a key role, for instance, by setting up communities of practice.

Previous studies have highlighted the importance of considering the local contexts when studying flood vulnerability and the processes underlying people's decision-making with regard to flood protection (Heidenreich et al., 2020; Rufat et al., 2015). This study is particularly relevant to the context of Quebec. It limits potential generalizations regarding the results, but ensures that the beliefs highlighted are significant in terms of crafting effective public health outreach in Quebec. Another

limitation is that it relies on self-reporting to measure adaptive behavior adoption. However, objective measurements would have been much more labor-intensive, considering the wide area covered by the study and the number of structural behaviors measured. This means that the participants may have exaggerated their behavior adoption rates, but some factors helped mitigate this potential problem, such as clear statements provided to the respondents that their responses were anonymous. In addition, self-reports are often used in other studies on pro-environmental behaviors (Bakhsh et al., 2018; Bichard & Kazmierczak, 2012; Chen & Liu, 2015), and the behavior adoption rates that we obtained are similar to those obtained in our other studies on flood prevention (Valois et al., 2019; Valois, Tessier, Bouchard, et al., 2020). Finally, the cross-sectional nature of the study is another important limitation in bringing a causal interpretation to the observed associations.

6 | CONCLUSION

This study contributes to the development of a better understanding of the determinants of the adoption of behaviors related to structural adaptation to flooding. Public authorities working to convince people to take action to protect their homes from flood impacts could benefit from information pertaining to specific individuals' beliefs regarding such actions. While the transmission of information to the public on structural adaptation is important, the effectiveness of such communication effort hinges on the development of messages that will reinforce positive beliefs about structural adaptation to flooding or change negative beliefs about such action. More specifically, these messages could focus on what important referents think an individual should do, for example by presenting positive testimonials of figures portraying neighbors, family members and friends. Communication could also emphasize the positive consequences likely to occur following the adoption of the targeted behaviors (e.g., benefit to physical and mental health; home maintaining its value), as well as the idea that adapting may turn out to be less complex than anticipated with support being made available. The methodology outlined in this study could be replicated in the future to develop a further understanding of factors influencing individuals' choices of adaptation measures, which would help refine our knowledge of the different profiles of individuals to attain, and from there develop specific messages.

ACKNOWLEDGMENTS

We gratefully acknowledge financial support from the 2013-2020 Climate Change Action Plan (PACC 2013-2020), funded by the Institut national de santé publique du Québec (INSPQ) (http://www.environnement.gouv.qc.ca/changements/plan_action/pacc2020.pdf). We thank the respondents who answered our survey and whose expressed views were the primary sources of information for this research.

FUNDING INFORMATION

DT was supported by a career award from the Fonds de recherche du Québec—Santé. The funders had no role in the study design, data collection and analysis, decision to publish, or preparation of the manuscript.

CONFLICT OF INTEREST STATEMENT

The authors declare that they have no competing interests.

DATA AVAILABILITY STATEMENT

The data that supports the findings of this study are available in the supplementary material of this article.

ORCID

Johann Jacob https://orcid.org/0000-0002-7354-950X

REFERENCES

Ajzen, I. (1985). From intentions to actions: A theory of planned behavior. In J. Kuhl & J. Beckman (Eds.), *Action-control: From cognition to behavior* (pp. 11–39). Springer.

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes*, *50*(2), 179–211. https://doi.org/10.1016/0749-5978(91)90020-T

Ajzen, I. (2012). The theory of planned behavior. In P. A. M. Lange, A. W. Kruglanski, & E. T. Higgins (Eds.), *Handbook of theories of social psychology* (Vol. 1, pp. 438–459). Sage.

Ajzen, I., & Fishbein, M. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Addison-Wesley.

Ajzen, I., Joyce, N., Sheikh, S., & Cote, N. G. (2011). Knowledge and the prediction of behavior: The role of information accuracy in the theory of planned behavior. *Basic and Applied Social Psychology*, *33*(2), 101–117. https://doi.org/10.1080/01973533.2011.568834

Ajzen, I., & Kruglanski, A. W. (2019). Reasoned action in the service of goal pursuit. *Psychological Review*, *126*(5), 774–786. https://doi.org/10.1037/rev0000155

Albright, E. A., & Crow, D. A. (2015). Learning processes, public and stakeholder engagement: Analyzing responses to Colorado's extreme flood events of 2013. *Urban Climate*, *14*, 79–93. https://doi.org/10.1016/j.uclim.2015.06.008

Babcicky, P., & Seebauer, S. (2019). Unpacking protection motivation theory: Evidence for a separate protective and non-protective route in private flood mitigation behavior. *Journal of Risk Research*, *22*(12), 1503–1521. https://doi.org/10.1080/13669877.2018.1485175

Bakhsh, K., Rauf, S., & Zulfiqar, F. (2018). Adaptation strategies for minimizing heat wave induced morbidity and its determinants. *Sustainable Cities and Society*, *41*, 95–103. https://doi.org/10.1016/j.scs.2018.05.021

Bamberg, S., & Möser, G. (2007). Twenty years after Hines, Hungerford, and Tomera: A new meta-analysis of psycho-social determinants of pro-environmental behaviour. *Journal of Environmental Psychology*, *27*(1), 14–25. https://doi.org/10.1016/j.jenvp.2006.12.002

Bichard, E., & Kazmierczak, A. (2012). Are homeowners willing to adapt to and mitigate the effects of climate change? *Climatic Change*, *112*(3–4), 633–654. https://doi.org/10.1007/s10584-011-0257-8

Buttle, J. M., Allen, D. M., Caissie, D., Davison, B., Hayashi, M., Peters, D. L., Pomeroy, J. W., Simonovic, S., St-Hilaire, A., & Whitfield, P. H. (2016). Flood processes in Canada: Regional and special aspects. *Canadian Water Resources Journal / Revue Canadienne Des Ressources Hydriques*, *41*(1–2), 7–30. https://doi.org/10.1080/07011784.2015.1131629

Byrne, B. M. (2012). *Structural equation modeling with Mplus: Basic concepts, applications, and programming*. Routledge.

Carman, J. P., & Zint, M. T. (2020). Defining and classifying personal and household climate change adaptation behaviors. *Global Environmental Change*, *61*, 102062. https://doi.org/10.1016/j.gloenvcha.2020.102062

Chen, L., & Liu, A. (2015). The incidence of posttraumatic stress disorder after floods: A meta-analysis. *Disaster Medicine and Public Health Preparedness*, *9*(3), 329–333. https://doi.org/10.1017/dmp.2015.17

Clayton, S., Devine-Wright, P., Stern, P. C., Whitmarsh, L., Carrico, A., Steg, L., Swim, J., & Bonnes, M. (2015). Psychological research and global climate change. *Nature Climate Change*, *5*(7), 640–646. https://doi.org/10.1038/nclimate2622

de Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology*, *42*, 128–138. https://doi.org/10.1016/j.jenvp.2015.03.005

Deng, Y., Wang, M., & Yousefpour, R. (2017). How do people's perceptions and climatic disaster experiences influence their daily behaviors regarding adaptation to climate change?—A case study among young generations. *Science of the Total Environment*, *581-582*, 840–847. https://doi.org/10.1016/j.scitotenv.2017.01.022

Deville, J.-C., & Särndal, C.-E. (1992). Calibration estimators in survey sampling. *Journal of the American Statistical Association*, *87*(418), 376–382. https://doi.org/10.1080/01621459.1992.10475217

Dillenardt, L., Hudson, P., & Thieken, A. H. (2022). Urban pluvial flood adaptation: Results of a household survey across four German municipalities. *Journal of Flood Risk Management*, *15*(3), e12748. https://doi.org/10.1111/jfr3.12748

Fernandez, A., Black, J., Jones, M., Wilson, L., Salvador-Carulla, L., Astell-Burt, T., & Black, D. (2015). Flooding and mental health: A systematic mapping review. *PLoS One*, *10*(4), e0119929. https://doi.org/10.1371/journal.pone.0119929

Fishbein, M., & Ajzen, I. (2010). *Predicting and changing behavior: The reasoned action approach*. Psychology Press.

Généreux, M., Maltais, D., Lansard, A. L., & Gachon, P. (2020). Psychological impacts of the 2019 Quebec floods: Findings from a large population-based study. *European Journal of Public Health*, *30*(Suppl 5). https://doi.org/10.1093/eurpub/ckaa165.375

Gifford, R. (2011). The dragons of inaction: Psychological barriers that limit climate change mitigation and adaptation. *American Psychologist*, *66*(4), 290–302. https://doi.org/10.1037/a0023566

Gifford, R., Kormos, C., & McIntyre, A. (2011). Behavioral dimensions of climate change: Drivers, responses, barriers, and interventions. *Wiley Interdisciplinary Reviews: Climate Change*, *2*(6), 801–827. https://doi.org/10.1002/wcc.143

Gifford, R., & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behaviour: A review. *International Journal of Psychology*, *49*(3), 141–157. https://doi.org/10.1002/ijop.12034

Grothmann, T., Grecksch, K., Winges, M., & Siebenhüner, B. (2013). Assessing institutional capacities to adapt to climate change: Integrating psychological dimensions in the adaptive capacity wheel. *Natural Hazards and Earth System Sciences*, *13*(12), 3369–3384. https://doi.org/10.5194/nhess-13-3369-2013

Grothmann, T., & Patt, A. (2005). Adaptive capacity and human cognition: The process of individual adaptation to climate change. *Global Environmental Change*, *15*(3), 199–213. https://doi.org/10.1016/j.gloenvcha.2005.01.002

Grothmann, T., & Reusswig, F. (2006). People at risk of flooding: Why some residents take precautionary action while others do not. *Natural Hazards*, *38*(1), 101–120. https://doi.org/10.1007/s11069-005-8604-6

Guha-Sapir, D., Below, R., & Hoyois, P. (2015). *Annual disaster statistical review 2014*. Centre for research on the Epidemiology of Disasters. Retrived from https://www.emdat.be/publications?page=3

Heidenreich, A., Masson, T., & Bamberg, S. (2020). Let's talk about flood risk!—Evaluating a series of workshops on private flood protection. *International Journal of Disaster Risk Reduction*, *50*, 101880. https://doi.org/10.1016/j.ijdrr.2020.101880

Hines, J. M., Hungerford, H. R., & Tomera, A. N. (1987). Analysis and synthesis of research on responsible environmental behavior: A meta-analysis. *The Journal of Environmental Education*, *18*(2), 1–8. https://doi.org/10.1080/00958964.1987.9943482

Hirabayashi, Y., Mahendran, R., Koirala, S., Konoshima, L., Yamazaki, D., Watanabe, S., Kim, H., & Kanae, S. (2013). Global flood risk under climate change. *Nature Climate Change*, *3*(9), 816–821. https://doi.org/10.1038/nclimate1911

Hu, L., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: A Multidisciplinary Journal*, *6*(1), 1–55. https://doi.org/10.1080/10705519909540118

IPCC, Annex II: Glossary, Möller, V., van Diemen, R., Matthews, J. B. R., Méndez, C., Semenov, S., Fuglestvedt, J. S., & Reisinger, A. (2022). In H.-O. Pörtner, D. C. Roberts, M. Tignor, E. S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, & B. Rama (Eds.), *Climate change 2022: Impacts, adaptation and vulnerability. contribution of working group II to the sixth assessment report of the intergovernmental panel on climate change* (pp. 2897–2930). Cambridge University Press. https://doi.org/10.1017/9781009325844.029

Jermacane, D., Waite, T. D., Beck, C. R., Bone, A., Amlôt, R., Reacher, M., Kovats, S., Armstrong, B., Leonardi, G., James Rubin, G., & Oliver, I. (2018). The English National Cohort Study of Flooding and Health: The change in the prevalence of psychological morbidity at year two. *BMC Public Health*, *18*(1), 330. https://doi.org/10.1186/s12889-018-5236-9

Kim, H. S., Bigman, C. A., Leader, A. E., Lerman, C., & Cappella, J. N. (2012). Narrative health communication and behavior change: The influence of exemplars in the news on intention to quit smoking. *The Journal of Communication*,

62(3), 473–492. https://doi.org/10.1111/j.1460-2466.2012.01644.x

Kline, R. B. (2015). *Principles and practice of structural equation modeling* (4th ed.). Guilford Press.

Klöckner, C. A. (2013). A comprehensive model of the psychology of environmental behaviour—A meta-analysis. *Global Environmental Change*, *23*(5), 1028–1038. https://doi.org/10.1016/j.gloenvcha.2013.05.014

Kuhlicke, C., Seebauer, S., Hudson, P., Begg, C., Bubeck, P., Dittmer, C., Grothmann, T., Heidenreich, A., Kreibich, H., Lorenz, D. F., Masson, T., Reiter, J., Thaler, T., Thieken, A. H., & Bamberg, S. (2020). The behavioral turn in flood risk management, its assumptions and potential implications. *WIREs Water*, *7*(3), e1418. https://doi.org/10.1002/wat2.1418

Kundzewicz, Z. W., Kanae, S., Seneviratne, S. I., Handmer, J., Nicholls, N., Peduzzi, P., Mechler, R., Bouwer, L. M., Arnell, N., Mach, K., Muir-Wood, R., Brakenridge, G. R., Kron, W., Benito, G., Honda, Y., Takahashi, K., & Sherstyukov, B. (2014). Flood risk and climate change: Global and regional perspectives. *Hydrological Sciences Journal*, *59*(1), 1–28. https://doi.org/10.1080/02626667.2013.857411

Little, T. D., Bovaird, J. A., & Widaman, K. F. (2006). On the merits of orthogonalizing powered and product terms: Implications for modeling interactions among latent variables. *Structural Equation Modeling: A Multidisciplinary Journal*, *13*(4), 497–519. https://doi.org/10.1207/s15328007sem1304_1

Malbeuf, J. (2020, August 4). Fort McMurray spring flood caused $522 million in damage, insurance bureau says. *CBC News*. https://www.cbc.ca/news/canada/edmonton/fort-mcmurray-flood-damage-1.5673962

MAMH. (2020). *Plan de protection du territoire face aux inondations: Des solutions durables pour mieux protéger nos milieux de vie. Ministère des Affaires municipales et de l'Habitation*. Retrieved from https://cdn-contenu.quebec.ca/cdn-contenu/adm/min/affaires-municipales/publications-adm/documents/plan_protection_territoire_inondations/PLA_inondations.pdf?1634924214

Meinel, U., & Höferl, K.-M. (2017). Non-adaptive behavior in the face of climate change: First insights from a behavioral perspective based on a case study among firm managers in alpine Austria. *Sustainability*, *9*(7), 1132. https://doi.org/10.3390/su9071132

Milly, P. C. D., Wetherald, R. T., Dunne, K. A., & Delworth, T. L. (2002). Increasing risk of great floods in a changing climate. *Nature*, *415*, 514–517. https://doi.org/10.1038/415514a

Mondal, M. S. H., Murayama, T., & Nishikizawa, S. (2021). Examining the determinants of flood risk mitigation measures at the household level in Bangladesh. *International Journal of Disaster Risk Reduction*, *64*, 102492. https://doi.org/10.1016/j.ijdrr.2021.102492

Moudrak, N., Feltmate, B., Venema, H., & Osman, H. (2015). Combatting Canada's rising flood costs: Natural infrastructure is an underutilized option. Retrieved from http://assets.ibc.ca/Documents/Resources/IBC-Natural-Infrastructure-Report-2018.pdf

Muthén, L. K., & Muthén, B. O. (2017). *Mplus user's guide* (8th ed.). Muthén & Muthén. Retrieved from https://www.statmodel.com/download/usersguide/MplusUserGuideVer_8.pdf

Natural resources Canada. (2006). *Climate change in Quebec*. Retrieved from http://ftp.geogratis.gc.ca/pub/nrcan_rncan/publications/ess_sst/212/212816/gscmr_78_f_2001_pr01.pdf

Natural resources Canada. (2017). *Canada in a changing climate*. Natural resources Canada. Retrieved from https://www.nrcan.gc.ca/environment/impacts-adaptation/19918

Noll, B., Filatova, T., Need, A., & Taberna, A. (2022). Contextualizing cross-national patterns in household climate change adaptation. *Nature Climate Change*, *12*, 30–35. https://doi.org/10.1038/s41558-021-01222-3

Novikova, S. I., Richman, D. M., Supekar, K., Barnard-Brak, L., & Hall, D. (2013). Chapter three—NDAR: A model Federal System for secondary analysis in developmental disabilities research. In R. C. Urbano (Ed.), *International review of research in developmental disabilities* (Vol. 45, pp. 123–153). Academic Press. https://doi.org/10.1016/B978-0-12-407760-7.00003-7

Oreg, S., & Katz-Gerro, T. (2006). Predicting Proenvironmental behavior cross-nationally: Values, the theory of planned behavior, and value-belief-norm theory. *Environment and Behavior*, *38*(4), 462–483. https://doi.org/10.1177/0013916505286012

Oubennaceur, K., Chokmani, K., Lessard, F., Gauthier, Y., Baltazar, C., & Toussaint, J.-P. (2022). Understanding flood risk perception: A Case Study from Canada. *Sustainability*, *14*(5), 3085. https://doi.org/10.3390/su14053087

Rogers, R. W. (1983). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In J. T. Cacioppo & R. E. Petty (Eds.), *Social psychophysiology: A sourcebook* (pp. 153–176). Guilford Press.

Rosenstock, I. M. (1974). The health belief model and preventive health behavior. *Health Education & Behavior*, *2*(4), 354–386. https://doi.org/10.1177/109019817400200405

Rufat, S., Tate, E., Burton, C. G., & Maroof, A. S. (2015). Social vulnerability to floods: Review of case studies and implications for measurement. *International Journal of Disaster Risk Reduction*, *14*, 470–486. https://doi.org/10.1016/j.ijdrr.2015.09.013

Saint-Arnaud, P. (2019). Les inondations, événement climatique de 2019. *La Presse* https://www.lapresse.ca/actualites/environnement/2019-12-24/les-inondations-evenement-climatique-de-2019#:~:text=Les%20donn%C3%A9es%20qu'a%20pu,pour%20l'ensemble%20du%20Qu%C3%A9bec

Stead, M., Tagg, S., MacKintosh, A. M., & Eadie, D. (2005). Development and evaluation of a mass media theory of planned behaviour intervention to reduce speeding. *Health Education Research*, *20*(1), 36–50. https://doi.org/10.1093/her/cyg093

Steinmetz, H., Knappstein, M., Ajzen, I., Schmidt, P., & Kabst, R. (2016). How effective are behavior change interventions based on the theory of planned behavior?: A three-level meta-analysis. *Zeitschrift für Psychologie*, *224*(3), 216–233. https://doi.org/10.1027/2151-2604/a000255

Sterling, S. (2011). Transformative learning and sustainability: Sketching the conceptual ground. *Learning and Teaching in Higher Education*, *5*, 17–33.

Stern, P. C. (2011). Contributions of psychology to limiting climate change. *American Psychologist*, *66*(4), 303–314. https://doi.org/10.1037/a0023235

Swim, J. K., Stern, P. C., Doherty, T. J., Clayton, S., Reser, J. P., Weber, E. U., Gifford, R., & Howard, G. S. (2011). Psychology's contributions to understanding and addressing global climate change. *American Psychologist*, *66*(4), 241–250. https://doi.org/10.1037/a0023220

Tarka, P. (2018). An overview of structural equation modeling: Its beginnings, historical development, usefulness and controversies in the social sciences. *Quality & Quantity: International*

Journal of Methodology, *52*(1), 313–354. https://doi.org/10.1007/s11135-017-0469-8

Terpstra, T., & Lindell, M. K. (2013). Citizens' perceptions of flood hazard adjustments: An application of the protective action decision model. *Environment and Behavior*, *45*(8), 993–1018. https://doi.org/10.1177/0013916512452427

Tomarken, A. J., & Waller, N. G. (2005). Structural equation modeling: Strengths, limitations, and misconceptions. *Annual Review of Clinical Psychology*, *1*(1), 31–65. https://doi.org/10.1146/annurev.clinpsy.1.102803.144239

Valois, P., Bouchard, D., Aenishaenslin, C., Talbot, D., Bouchard, C., Briand, S., & Tessier, M. (2020). Development and validation of a behavioral index for adaptation to Lyme disease. *BMC Public Health*, *20*, 1435. https://doi.org/10.1186/s12889-020-09535-2

Valois, P., Bouchard, D., Talbot, D., Caron, M., Renaud, J.-S., Gosselin, P., & Jacob, J. (2020). Adoption of flood-related preventive behaviours by people having different risks and histories of flooding. *Natural Hazards.*, *102*, 1155–1173. https://doi.org/10.1007/s11069-020-03950-9

Valois, P., Caron, M., Gousse-Lessard, A.-S., Talbot, D., & Renaud, J.-S. (2019). Development and validation of five behavioral indices of flood adaptation. *BMC Public Health*, *19*(1), 245. https://doi.org/10.1186/s12889-019-6564-0

Valois, P., Renaud, J.-S., Talbot, D., Carrier, M.-P., & Caron, M. (2017). *Adaptation des personnes habitant une zone inondable*: *Identification des croyances dominantes*. Retrieved from https://oqacc.ca/publications/adaptation-des-personnes-habitant-une-zone-inondable-identification-des-croyances-dominantes/

Valois, P., Talbot, D., Bouchard, D., Renaud, J.-S., Caron, M., Canuel, M., & Arrambourg, N. (2020). Using the theory of planned behavior to identify key beliefs underlying heat adaptation behaviors in elderly populations. *Population and Environment*, *41*, 480–506. https://doi.org/10.1007/s11111-020-00347-5

Valois, P., Tessier, M., Bouchard, D., Talbot, D., Morin, A. J. S., Anctil, F., & Cloutier, G. (2020). Monitoring the evolution of individuals' flood-related adaptive behaviors over time: Two cross-sectional surveys conducted in the province of Quebec. *Canada. BMC Public Health*, *20*, 1643. https://doi.org/10.1186/s12889-020-09763-6

van Valkengoed, A. M., Perlaviciute, G., & Steg, L. (2022). Relationships between climate change perceptions and climate adaptation actions: Policy support, information seeking, and behaviour. *Climatic Change*, *171*(1), 14. https://doi.org/10.1007/s10584-022-03338-7

Wang, C., Zhang, J., Cao, J., Hu, H., & Yu, P. (2019). The influence of environmental background on tourists' environmentally responsible behaviour. *Journal of Environmental Management*, *231*, 804–810. https://doi.org/10.1016/j.jenvman.2018.10.089

Wilson, R. S., Herziger, A., Hamilton, M., & Brooks, J. S. (2020). From incremental to transformative adaptation in individual responses to climate-exacerbated hazards. *Nature Climate Change*, *10*(3), 200–208. https://doi.org/10.1038/s41558-020-0691-6

Yazar, M., York, A., & Kyriakopoulos, G. (2021). Heat exposure and the climate change beliefs in a Desert City: The case of Phoenix metropolitan area. *Urban Climate*, *36*, 100769. https://doi.org/10.1016/j.uclim.2020.100769

Zhang, L., Ruiz-Menjivar, J., Luo, B., Liang, Z., & Swisher, M. E. (2020). Predicting climate change mitigation and adaptation behaviors in agricultural production: A comparison of the theory of planned behavior and the value-belief-norm theory. *Journal of Environmental Psychology*, *68*, 101408. https://doi.org/10.1016/j.jenvp.2020.101408

Zhong, S., Yang, L., Toloo, S., Wang, Z., Tong, S., Sun, X., Crompton, D., FitzGerald, G., & Huang, C. (2018). The long-term physical and psychological health impacts of flooding: A systematic mapping. *Science of the Total Environment*, *626*, 165–194. https://doi.org/10.1016/j.scitotenv.2018.01.041

Zoellner, J. M., Porter, K. J., Chen, Y., Hedrick, V. E., You, W., Hickman, M., & Estabrooks, P. A. (2017). Predicting sugar-sweetened behaviours with theory of planned behaviour constructs: Outcome and process results from the SIPsmartER behavioural intervention. *Psychology & Health*, *32*(5), 509–529. https://doi.org/10.1080/08870446.2017.1283038

Zografos, C., Anguelovski, I., & Grigorova, M. (2016). When exposure to climate change is not enough: Exploring heatwave adaptive capacity of a multi-ethnic, low-income urban community in Australia. *Urban Climate*, *17*, 248–265. https://doi.org/10.1016/j.uclim.2016.06.003

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Jacob, J., Valois, P., Tessier, M., Talbot, D., Anctil, F., Cloutier, G., & Renaud, J.-S. (2023). Using the theory of planned behavior to identify key beliefs underlying flood-related adaptive behaviors in the province of Québec, Canada. *Journal of Flood Risk Management*, e12906. https://doi.org/10.1111/jfr3.12906