International Journal of Disaster Risk Reduction 37 (2019) 101147

Contents lists available at ScienceDirect

International Journal of Disaster Risk Reduction

journal homepage: www.elsevier.com/locate/ijdrr

Public perceptions and information seeking intentions related to seismicity in five Texas communities

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ARTICLE INFO

Keywords:
Risk information seeking
Information behavior
Induced seismicity
Texas seismicity
PRISM

ABSTRACT

Texas has experienced levels of seismicity comparable to areas of California in recent years, and seismologists suggest that the increased activity in Texas is likely the result of human activities associated with oil and gas extraction. However, the general public is largely unaware of induced seismicity and related risks. To better understand this lack of awareness and how it might be addressed, we sought guidance from Kahlor's (2010) planned risk information seeking model to explore the social-psychological factors that are likely to influence Texan's intentions to seek information about the potential risks posed by earthquakes. We test the model using data collected from residents in five Texas communities that have varied experiences with seismicity. The data supports the model: the variance in intentions to seek information about earthquake risks were largely explained by positive attitudes towards seeking such information, perceived control over the ability to seek such information, perceived social pressure related to seeking such information, perceived earthquake risks, risk-related emotion (e.g., worry) and a perceived need for more information about earthquake risks. The study highlights the applicability of this risk information-seeking model to the context of seismic risk, and suggests ways in which scientists and communicators might engage the public more effectively with the topic.

1. Introduction

According to the United States Geological Survey (2017), between 1973 and 2008 there were 542 seismic events; between 2009 and 2016 that number was 8513. Research suggests that the increase is, in part, the result of seismicity that is induced by human activities related to oil and gas production – specifically wastewater fluid injection that activates nearby subsurface faults [1]. The adjacent state of Oklahoma has seen a similar rise in induced seismic events [2]; the Oklahoma events resulted in personal injuries, as well as damaged homes, businesses, and community infrastructures [3,4]; The [5]. These negative outcomes have garnered increased public attention to seismic risk and increased coverage of induced seismicity in the mass media [3,4,6]; Office of the Oklahoma Secretary of Energy and Environment, 2017). For example, a recent study of newspaper coverage of induced seismicity in Texas, Oklahoma and Ohio found an increase in such news reports from 2009 to 2014 [7].

However, social scientific research related to seismic risks and the increased mass media coverage of seismic events – induced or natural – has been limited, both in the U.S. and abroad. The research that has emerged is focused on perceptions of seismicity in terms of locus of control, self-efficacy, stress vulnerability and risk susceptibility in Romania [8]; the cost and benefit evaluations of seismicity related to energy development in the U.S. [9]; and the relationship between information seeking and perceived earthquake risk in the U.S [10,11].

Building on this nascent research and given the heightened need for information about seismicity brought on by the more than tenfold increase of seismic events in Texas since 2008, the primary purpose of the current study is to explore predictors of information seeking related to seismic risk. We turned to the planned risk information seeking model (PRISM [12], to guide this work. PRISM robustly predicts risk information seeking intentions and provides a framework for understanding how people deal with risk across contexts and populations. However, it has rarely been studied in a potential disaster risk context. Eastin, Kahlor, Liang and Abi Ghannam (2015) have utilized PRISM to explore individuals' precautionary behavior to hydraulic fracturing risk associated with shale gas development, however their study focused on environmental risks (for example, air pollution and underground water

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https://doi.org/10.1016/j.ijdrr.2019.101147
Received 14 June 2018; Received in revised form 3 April 2019; Accepted 6 April 2019
Available online 16 April 2019

contamination), which is different from the disaster risk in nature. So with the current study, we also aim to offer a starting point for understanding an emerging risk communication context, such as seismicity. This application will help us to better undertand if the model applies to emerging risks as they are understood in local communities.

2. Literature review

2.1. Risk information seeking

PRISM [12] is rooted in Ref. [13] risk information seeking and processing model. The risk information seeking and processing model integrated concepts from earlier research on information seeking, information processing and risk perception and its key components are individual characteristics (such as experience with a risk), perceived hazard characteristics (in which risk perception is often included), affective response to a risk (typically worry), perceived social pressure to be informed (also labeled as informational subjective norms), the perception that one currently has insufficient knowledge about the risk (perceived information insufficiency), perceived information gathering capacity (akin to self-efficacy), and beliefs about communication channels (including whether they are biased).

Centering the concept of risk in studies that focus on information seeking related to potential threats (such as earthquakes) is key to this work. As Slovic explains, when lay people are asked about novel threats and related information, "they seldom have statistical evidence on hand. In most cases, they must make inferences based on what they remember hearing or observing about the risk in question. Research has identified a number of general inferential rules that people use in such situations. These rules, known as heuristics, are employed to reduce difficult mental tasks to simpler ones" [14]; p. 18).

Heavily influenced by the heuristic systematic model of information processing [15–17], the risk information seeking and processing model relies heavily on the sufficiency principle, which states "perceivers who are motivated to determine accurate judgments will exert as much cognitive effort as is necessary (and possible) to reach a sufficient degree of confidence that their judgments will satisfy their accuracy goals" [18]; p. 74) [13]. further refined the sufficiency principle into the concept of information insufficiency, which describes the gap between what one already knows and what one desires to know [13]. The risk information seeking and processing model also builds on two concepts from Ref. [19] Theory of Planned Behavior model: informational subjective norms and perceived information gathering capacity (akin to Ajzen's perceived behavioral control). The risk information seeking and processing model has been applied to various contexts including, but not limited to, climate change [20,21], cancer clinical trials [22], and urban flooding [23].

Building on the risk information seeking and processing model [12], PRISM also maps predictors of risk information seeking, but was more substantially informed by the theory of planned behavior [19]. The theory of planned behavior asserts that information seeking intention is guided by: (1) attitude toward the behavior, which is favorable/unfavorable evaluations of the behavior, (2) perceived social pressure from others to perform or not perform the behavior, also known as subjective norms, and (3) one's perceived ability to perform a behavior, or perceived behavioral control [19]. The theory of planned behavior has been celebrated and supported for decades across various behaviors and contexts, such as voting behaviors [24], shoplifting [25], and recycling [26]. PRISM adapts all three of the theory of planned behavior variables (i.e., attitudes toward the behavior, perceived behavioral control, and subjective norms) and validates that they have direct effects on information seeking intention. Additionally, PRISM borrows the concepts of risk perception, affective response to risk, and information insufficiency from the risk information seeking and processing model (see Fig. 1). PRISM suggests that risk information seeking intent is directly predicted by three variables from the theory of planned behavior – attitudes toward the behavior, subjective norms, and perceived behavioral control – as well as affective response to the risk and knowledge insufficiency. This approach distinguishes PRISM from the risk information seeking and processing model, which has model predictors working primarily through information insufficiency in their impact on seeking. Thus far, PRISM has been tested within health and environmental risks [12,27–29], including hydraulic fracturing [30].

One-way arrows indicate predictive relationships; two-way arrows indicate correlations.

The current study applies PRISM to the context of earthquakes with the intention to (1) test whether PRISM is viable for explaining variance in individuals' intentions to seek information in this risk context, and (2) introduce PRISM as a guide for exploring possible strategies to increase public awareness of seismicity and associated risks. The next section spells out PRISM variables in more detail.

2.2. Key components in PRISM

The key dependent variable in PRISM is **information seeking intentions**. Much of the early work related to behavioral intentions and behaviors has shown that intention, in general, accurately predicts actual behavior [19] "when behaviors pose no serious problems of control" (p. 186). As such, PRISM treats seeking intention as a key outcome variable that can be captured in cross-sectional data and used as a proxy for subsequent information seeking that may occur further down the road – this approach is important when researching novel topics with low public awareness or when establishing a baseline for information seeking motivations related to a novel topic.

The following variables, as previously mentioned, are adapted directly from Ref. [19] theory and are equally important to PRISM.

Attitude toward seeking. The conceptualization of attitude is "the degree to which a person has a favorable or unfavorable evaluation or appraisal of the behavior in question" [19]; p.188). Generally, attitudes towards a behavior contribute significantly to the prediction of behavioral intention, thus actual behavior. In short, the more favorable the evaluation is toward the behavior, the more likely one will perform the behavior. In PRISM, attitude is proposed to directly impact perceived knowledge [31], perceived knowledge insufficiency [32,33], as well as seeking intention [19].

Seeking-related subjective norms. Conceptualized as the perceived social pressure or normative forces to perform or not perform a particular behavior, social norms are a strong predictor of people's actual behavioral achievements [19]. Seeking-related subjective norms cover both injunctive norms, that is, pressure from important others who think the individual should do or not do, and descriptive norms, which come from observations of these others also doing the behavior. Informational subjective norms have helped to explain variance in information seeking and processing behaviors through the concept of information sufficiency, especially in the context of environmental risks [34–36]. In PRISM specifically, seeking-related subjective norms also are proposed to directly impact perceived knowledge [31], perceived knowledge insufficiency [13], as well as seeking intention [19].

Perceived seeking control. A synonym for [37] perceived self-efficacy, perceived behavior control is "the perceived ease of performing the behavior" [13] and also a predictor of seeking intention [19]. The application of perceived seeking control has focused on preventive behaviors in the health context. Specifically, perceived seeking control captures both self-belief regarding how one could perform a preventive behavior, as well as the effectiveness of the preventive behavior [13]. Goldin and Kok (1996) found that, on average, perceived behavior control has explained 41% of the variance in behavioral intention in health context and 34% of the actual behavior. In PRISM, perceived seeking control impacts seeking intent [19], perceived knowledge insufficiency [13,33], and perceived current knowledge [31].

Perceived Knowledge and Knowledge Insufficiency. Risk

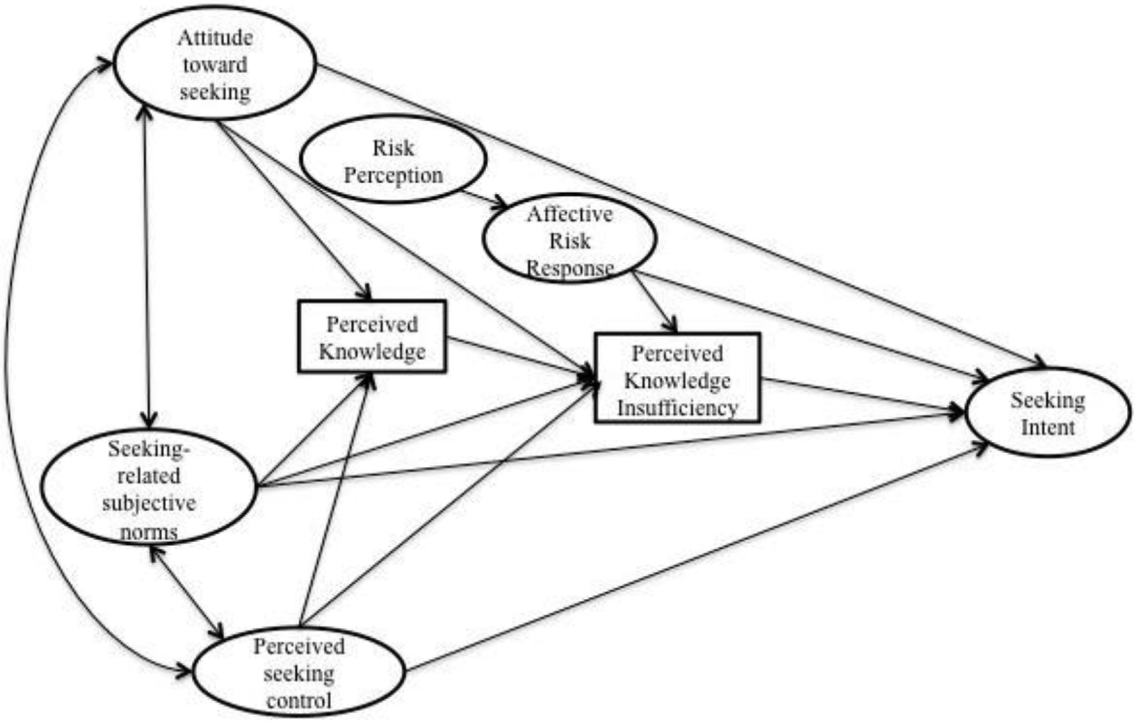

Fig. 1. The planned risk information seeking model.

information seeking is a planned, purposive knowledge acquisition process that is driven by, first and foremost, the perception that one lacks the knowledge needed to deal adequately with a topic (e.g., Refs. [13,38,39]. Perceived knowledge insufficiency is the gap between the amount of knowledge about a given topic that an individual thinks she needs and the amount of knowledge she thinks she currently has (i.e., perceived knowledge). Information insufficiency positively predicts information-seeking intention in PRISM [27,28]. Other factors also impact insufficiency; insufficiency is influenced by seeking-related subjective norms [13], attitude toward seeking and perceived seeking control [33], and affective response to risk [13]; see definition below).

The integral concept of perceived current knowledge also factors into PRISM beyond its relationship with insufficiency. According to Ref. [31] perceived current knowledge is, in part, determined also by the attitudes toward seeking, seeking-related subjective norms and perceived seeking control that resulted from past seeking efforts. According to Ref. [12]; "past experiences with perceived utility and experiential aspects of past seeking (both components of attitude toward seeking), information accessibility and understandability (components of control), and perceived social norms are all likely to impact one's assessment of one's current knowledge—both in terms of its adequacy and whether it is cause for uncertainty in the face of a new stimulus" (p. 348).

Risk Perception. A risk needs to first register in an individuals' mind before any subsequent action will take place. Scholars of risk tend to conceptualize this process of registering the risk as risk perception. Typical characteristics of risk perception include whether the risk is controllable, observable, voluntary, catastrophic, fatal, immediate, and/or increasing or decreasing [40]. In general, risk has two dimensions: perception of likelihood or probability of the risk occurring, and the perceived severity or magnitude of the risk [41]. Studies have generally supported that these two dimensions are positively correlated with affective response to risk [13]; see affective response to risk defined below).

Affective Risk Response. Stronger risk perceptions lead to stronger affective responses, which can be positive and/or negative [13]. The powerful "feeling of dread" [40]; p. 121) is the most studied affective response in the risk perception literature; thus, PRISM research tends to focus on the effect of negative affective responses such as fear and worry on information seeking intention. Affective risk response directly impacts knowledge insufficiency [13] and information seeking intention [12,33,42]. Previous research also has shown fear can trigger more effortful information processing [43,44]. However, the positive relationship between fear and effortful processing only occurs when the emotion is not too extreme, as extreme fear can lead to information avoidance [33].

2.3. Hypotheses

The following hypotheses are suggested by the literature just discussed (see Fig. 2).

H1. Attitude toward seeking is positively related to information-seeking intent.

H2. Seeking-related subjective norms is positively related to information-seeking intent.

H3. Perceived seeking control is positively related to information-seeking intent.

H4. Risk perception is positively related to affective risk response.

H5. Affective risk response is positively related to information seeking intent.

H6. Perceived knowledge insufficiency is positively related to information seeking intent.

H7. Attitude toward seeking is positively related to perceived knowledge insufficiency.

H8. Seeking-related subjective norm is positively related to perceived knowledge insufficiency.

H9. Perceived seeking control (efficacy) is positively related to perceived knowledge insufficiency.

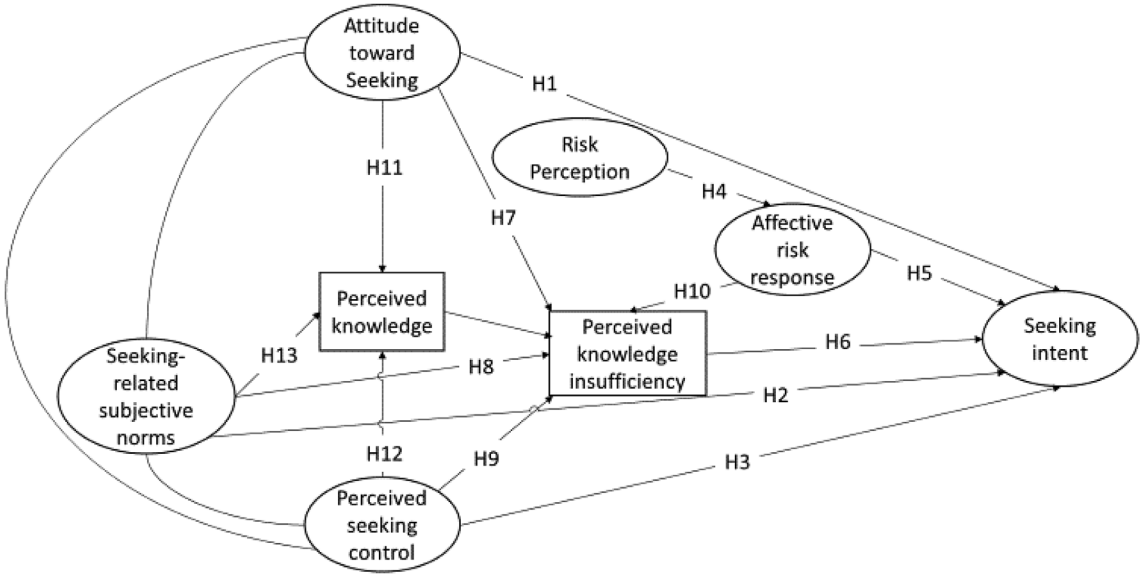

Fig. 2. Proposed relationships in PRISM.

H10. Affective risk response is positively related to perceived knowledge insufficiency.

H11. Attitude toward seeking is positively related to perceived knowledge.

H12. Perceived seeking control is positively related to perceived knowledge.

H13. Seeking-related subjective norms is positively related to perceived knowledge.

3. Material and methods

3.1. Study area and participants

Taking induced earthquakes into consideration, the United States Geological Survey's annual seismic risk forecast map noted that some areas of Texas, the Dallas-Fort Worth metroplex area for example, suffer a similar level of seismic risk as areas in California (United States Geological Survey, 2016, [45]. To understand the seismic risk perceptions and related information behavior among Texans, this current survey sampled five Texas communities in consultation with seismologists and geologists from the Bureau of Economic Geology at The University of Texas at Austin. The sampled communities were chosen because they a) historically experienced seismicity in Texas (Scurry County); b) only very recently experienced seismicity in Texas (Dallas); c) are expected, because of their specific location in the Permian Basin, to potentially experience increased induced seismic activity in the future (Monahans); or d) have not historically experienced nor are expected to experience seismicity in the future (Uvalde and Houston).

We sampled five communities with different seismic risk experiences in order to increase variability in experience with and exposure to seismicity and related information, and to allow for a comparative analysis across communities. On the latter, we conducted an ANOVA analysis to examine participants' risk perception across the different communities. The results suggest that participants' risk perception of induced earthquakes did not differ significantly across the communities ($F = 2.38$, $p > .05$). We suspect that this is due, in part, to risk perceptions being consistently low across Texas, even in areas with elevated risk. So in the analysis reported below, we explore Texans' earthquake risk information behavior across the whole sample (rather than comparatively by community).

A multi-mode rolling survey (mailing, online, and telephone) was fielded by a survey center at Sam Houston State University from June 15, 2016 to December 19, 2016. The random sampling frame was purchased from Marketing Systems Group and Survey Sampling International. The survey took about 20 min to complete and focused on participants' knowledge of, attitude toward, and risk perceptions related to seismicity in Texas. Our response rate was low (11%), however, the final sample size provides a snapshot of respondents' perceptions of seismicity in the targeted communities, as well as baseline data for future stakeholders. After cleaning the data and removing cases less than 75% complete, we obtained a total of 505 valid cases.

The age range of the final sample is 19–95 ($M = 60.86$, $SD = 16.84$). The education level ranges from "less than high school" to graduate degree (*mode* = bachelor's degree), and the median annual household income range was US$60,000 - US$69,999. In addition, 72% of the participants identified as White, and 55% identified as female. More than 100 survey items were used in the survey to understand Texans' overall seismic risk perception and related information behaviors. The current study focuses on a subset of variables, namely the PRISM constructs as well as several additional demographic variables.

3.2. Measures

The following measures are also featured in the Appendix. All items come from scales validated in prior research [12,20,28,30].

Attitude toward seeking. Attitudes are favorable or unfavorable evaluations of an attitude object – in this case, risk information seeking. According to Ref. [46] attitude has instrumental and experiential dimensions. To capture both, our scale used five 5-point sematic differential items (worthless/valuable, bad/good, harmful/beneficial, unhelpful/helpful, unproductive/productive) to measure individuals' attitudes toward risk information seeking, with lower scores indicating less favorable attitudes ($\alpha = 0.92$, $M = 3.67$, $SD = 1.19$).

Seeking-related subjective norms. Seeking-related subjective norms describe the individual's perception of others' expectations that the individual seek information about a risk topic. As defined by Ref. [46]; such behavioral norms contain descriptive and injunctive dimensions; injunctive norms measure perceptions about others' expectations and descriptive norms reflect the perception that others are also doing the behavior. Eight 5-point Likert items were used in the scale ($\alpha = 0.94$, $M = 2.24$, $SD = 0.85$).

Perceived seeking control. Perceived seeking control was measured

by four 5-point Likert items ($\alpha = 0.82$, $M = 3.57$, $SD = 0.89$) focused on individual's perception of their internal control (cognitive or physical ability to conduct the behavior) and external control (accessibility of the necessary resources) over seeking information about earthquake risks. These items, borrowed from Ref. [13]; include "I know how to search for information about the potential risks posed by earthquakes," "When it comes to information about the potential risks posed by earthquakes, I know how to separate fact from fiction," and "When it comes to finding information about the potential risks posed by earthquakes, I know what to do," which reflect the individual' perceptions of their own seeking ability. The item "I can readily access information about the potential risks posed by earthquakes" measures the perceived ease of obtaining the information.

Risk perception and affective risk response. Based on [14] measures of risk perception should, in the very least, reflect individual's heuristic evaluations of the seriousness of the threat and the personal risk it poses. So we included questions on perceived level of personal risk posed by earthquakes, perceived seriousness of that personal risk, likelihood of personal impact from the risk, and perceived severity of that impact ($\alpha = 0.86$, $M = 2.57$, $SD = 2.17$). Participants were required to rate their response from 0 to 10, with lower score indicating lower risk, severity, etc. Affective risk response was captured by three items, using scales with a range from 0 to 10 (i.e. Not concerned/Very concerned, Not worried/Very worried, Not anxious/Very anxious; $\alpha = 0.88$, $M = 2.38$, $SD = 1.04$).

Perceived knowledge and information insufficiency. Consistent with [12,13]; we measured perceived knowledge with the question, "Rate your knowledge of the potential risks posed by earthquakes on a scale of 0–100, where zero means knowing nothing about the potential risks posed by earthquakes and 100 meaning knowing everything you could possibly know about the potential risk posed by earthquakes" ($M = 41.31$, $SD = 29.68$). To understand how much information is needed, the questionnaire also asked participants to "Estimate how much knowledge you need to deal adequately with the potential risks posed by earthquakes" ($M = 60.16$, $SD = 30.58$).[1] These items are juxtaposed in the analysis such that perceived knowledge contributes directly to information insufficiency.

Seeking intent. Seeking intent is our dependent variable, captured with five 5-point Likert scale items ($\alpha = 0.96$, $M = 2.76$, $SD = 1.12$). An example item read, "I will look for information related to potential risks posed by earthquakes in the near future." The items all referenced the near future or "soon."

3.3. Data analysis & results

Structural equation modeling (SEM) analysis was conducted in Mplus7 to test the proposed hypotheses (see Fig. 3 for results) and examine paths and model fit of PRISM in the earthquake context. A maximum likelihood robust estimater was used to account for issues with multivariate normality. Latent variables were constructed for attitude toward seeking, seeking-related subjective norms, perceived seeking control, risk perception, affective risk response and seeking intent. Two-step modeling verified the measurement model before adding the paths to test the structural model. All standardized factor loadings were greater than or equal to .64. Indicators of model fit included chi-square, comparative fit index (CFI; values close to or greater than 0.95), root mean square error approximation (RMSEA; values lower than 0.08), and standardized root mean residual (SRMR; values lower than 0.08) [47,48]. The fit of the measurement model was good: $\chi^2(362) = 797.25$ ($p < .001$), RMEA = 0.05 (90% CI [0.044, 0.053]), CFI = 0.95.

Proposed structural paths were then added to test Hypotheses 1–14. Results show PRISM fits the data well: $\chi^2(416) = 915.19$ ($p < .001$), RMEA = 0.06 (90% CI [0.045, 0.053]), CFI = 0.95, SRMR = 0.05. Most of our hypotheses were supported ($p < .05$), although not the relationships between perceived seeking control and insufficiency (H9), attitude toward seeking and perceived knowledge (H11), and perceived seeking control and perceived knowledge (H12). To obtain an R-square statistic, we also ran hierarchical multiple regression analysis using SPSS, the results of which suggested that PRISM variables accounted for 60% of variance in seeking intent, which is consistent with prior research [28].

4. Discussion

Our main goal of this study was to explore Texans' risk perceptions related to seismicity and their intentions to seek related information in the future. An established risk information seeking framework, PRISM, guided this research. The study results are consistent with prior PRISM-based research [27] and further support PRISM's effectiveness on predicting individual's risk information seeking intent in the context of environmental risks, in this case, seismicity in Texas. We also fully explored the predictors of risk information seeking intent suggested by previous PRISM research. Most of our hypotheses were supported by the sample data, and the PRISM variables together explained a significant amount of variance in Texans' intentions to seek risk information related to seismicity in the future.

The survey results showed that individuals' perceived need for risk information related to seismicity drives their seeking intent. Although this relationship was not found in a general risk context [12], it has been supported in personal risk contexts such as cancer [28]) and impersonal risk contexts such as climate change [27]. In the earthquake risk information seeking study conducted by Ref. [49] in Songyuan, China, similar results also were reported [49]. found that information need positively predicted earthquake information seeking. Together with other scholars' findings, our results imply that the more earthquake risk information individuals believe they need to know, the more likely they will be to seek information on potential earthquake risks. At first glance, this relationship may seem rather intuitive, however, science communicators have historically had a tendency to distribute scientific information in ways that do not always prioritize the needs of the intended information recipients [50].

Attitude toward seeking, seeking related subjective norms, and perceived seeking control also were found to have a direct positive effect on seeking intent. These results tell us that individuals who think seeking risk information about earthquakes is useful, expected of them, and something they can do relatively easily, will be more motivated to seek the information in the future. Indeed, expectations from others emerged as the most powerful predictor of risk information seeking in this context. The role that norms play in urging people to seek information is well documented in the research [12,28,30,35]. Such norms are social expectations about how to behave [12,19] and there is a strong link between perceived group norms and individual behavior [51]. However, it is also important to note, particularly in the case of novel topics, that individuals can misperceive group or community norms – this misinterpretation is called pluralistic ignorance [52]. For example, if a community does not speak openly about a topic such as earthquake risks, the perceived norm might be to ignore such information – regardless of whether that is an actual expectation in the community [53]. Thus, the ways in which norms are communicated across a community can affect individual norm perceptions.

Participants' perceived norms related to information seeking were fairly weak, even though our analysis showed that such norms had the strongest relationship with risk information seeking intentions. Such low normative expectations might have to do with what is referred to as

[1] These are the same measures used to capture perceived knowledge and information insufficiency in previous risk information seeking research [12,20,21,27,36,60]. Although 5-point [49] and 10-point scales [28] have also been applied to measure perceived knowledge and information insufficiency. When possible, the 100-point sale is preferred to maximize variance in the data.

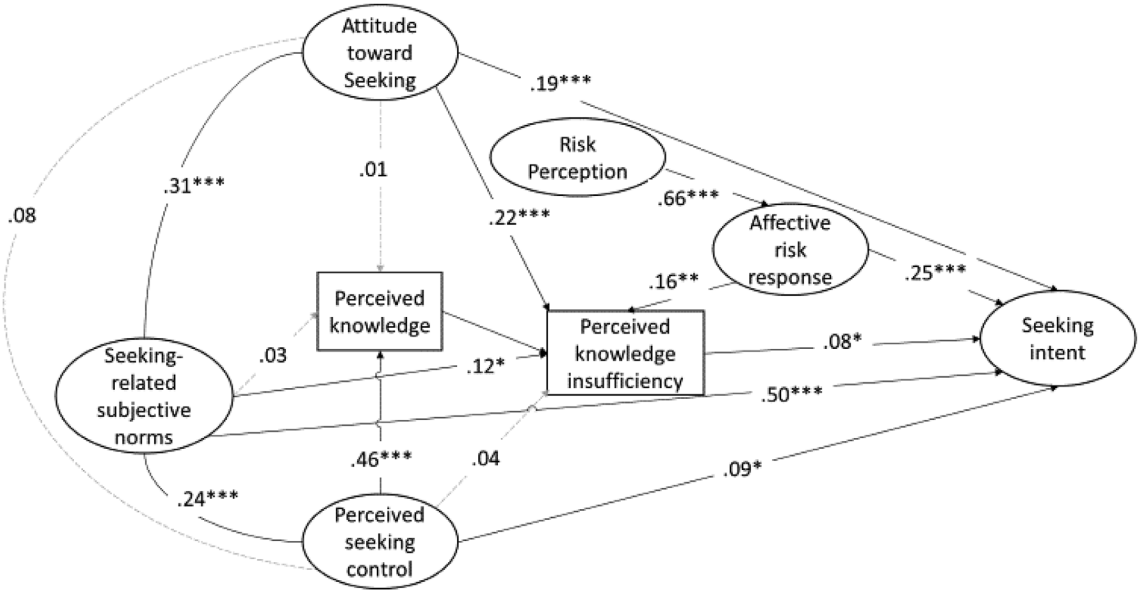

Fig. 3. PRISM Standardized path coefficients. *p < .05,**p < .01,***p < .001, absence of * indicates not significant.

"naïve psychology" among participants – which is the disinclination to recognize social influence in some situations [54]. Or it might have to do with pluralistic ignorance – the misperception of norms in groups or communities [52]. Regardless of potential causes, our findings show that subjective norms are strongly associated with risk information seeking, which suggests that message strategies intended to increase information seeking should highlight perceptions that the community expects its members to know something about the topic, in this case earthquake risks. This strategy might also highlight the risks and benefits associated with the energy extraction practices that contribute to induced earthquakes. In the data available to us, perceived risks include environmental problems, risks to future generations, and public health problems. Perceived benefits include less dependence on foreign oil, increased employment and local economic gain. As a result, messaging could signal that the community expects its members to know that local energy extraction practices must balance protection of future generations with local economic gain.

In addition, our results suggest that risk perception and affective risk response, especially negative affective risk response, are positively predictive of seeking intention. This finding is supported by previous risk information seeking studies [12,20], as well as other research that focuses on preventive behavior (for example, the Extended Parallel Processing Model; [55]. The takeaway is that both the cognitive and emotional perception of risk can drive seismic risk information seeking. For practitioners, highlighting negative emotions such as fear, worry or anxiety in message design could be a helpful strategy to motivate individuals' seeking behavior, especially as previous research has shown that increased information and media coverage already contribute to increased concern about induced earthquake risks [56,57]. Witte's Extended Parallel Processing Model suggests that messages that invoke moderate-level negative emotion and self-efficacy (in this case related to finding earthquake risk information) could be an effective strategy for motivating future seeking behavior.

Looking at predictors of perceived current knowledge, we see that perceived control had a significant relationship but seeking related subjective norms and attitude toward seeking did not [28]. found similar results in their study related to attitudes and suggested that past seeking experience could be moderating the relationship between attitude and current knowledge. This explanation could also be plausible for the current study, especially as people are not familiar with the topic of induced earthquakes. It was surprising to us that the relationship between subjective seeking norm and perceived knowledge was not supported in this study, which is usually a significant one in previous PRISM studies (e.g. Ref. [49]; Ho et al., 2016; [28]. One plausible reason is that the low rating of perceived information seeking norm in the sample suppressed the variance within the social norm construct.

In previous PRISM research, studies on disaster (for example, earthquake [49]; and other environmental risk context (such as climate change; Ho et al., 2016) reported their information seeking norm rating as above average score (e.g., higher than 3 on a 5-point Likert scale). However, the data collected from this current study indicated that participants' perceptions of seeking norms related to induced seismicity was lower ($M = 2.24$ on a 5-point scale). This phenomena could be explained by the fact that, as mentioned above, people are lacking awareness of and familiarity with induced earthquakes topic in the sampled communities. In Li et al.'s study, participants had a high familiarity with the risk as they just experienced a cluster of earthquakes, and the association between seeking norm and perceived knowledge in that study was the strongest ($b = 0.33$, $p < .001$). While in the Ho et al. study (2014), climate change was less likely to be directly experienced and the association is relatively less strong ($b = 0.15$, $p < .001$). Thus, the relationship between seeking norm and perceived knowledge across contexts might be affected by participants' familiarity with the risk topic.

Turning our attention to the predictors of perceived knowledge insufficiency, we see that affective risk response, attitude towards seeking and seeking-related subjective norm were significantly related to insufficiency; perceived seeking control was not. Thus, perceived seeking control is significantly related to perceived knowledge, but not to information insufficiency. This relationship indicates that higher seeking control is associated with higher knowledge levels, but it does not impact people's need for more information. [27,28] both reported similar results in their studies. As proposed by Ref. [34]; the relation between perceived seeking control and the current risk knowledge level might be reversed, which means that individuals will have higher self-efficacy related to seeking if they feel they know more on that topic. This relation can be explained by the knowledge gap assumption [58], which asserts that the more educated the individual is, the easier it is for the individual to obtain more information.

5. Conclusion and future research

Although the proposed relationships in PRISM are generally supported by prior research, we must reflect on Li et al.'s recent findings on

earthquake risk information seeking behavior (2017). Their research failed to find supportive evidence for the relationship between negative affective response, risk perception and seeking intent. The reason they provided is that their population had recently experienced a number of earthquakes. Thus, participants' emotions and concerns toward the earthquake had likely already peaked and were perhaps even somewhat numbed after the swath of disasters, which worked to reduce their seeking intent. The different findings between Li et al.'s research and our current study imply that individuals' visceral experience of earthquakes may be an important factor in their risk information seeking behavior. The impact of visceral experiences on risk perception is not a new topic (e.g. Ref. [59]; however, there is no current research that explores the role of visceral experience in predicting individual's risk information seeking behavior. This unexplored role is an interesting topic for future attention. Also, consistent with prior PRISM studies, we only examined the function of negative affect in the model; positive emotion might also be a promising direction for future research.

Finally, some limitations of this study should be noted. First, our sample was collected by mixed-mode methods across two waves and the response rate was low (11%). This low response rate may be due to a lack of interest in and awareness of seismicity among Texans. Our survey contractor reported that many people reached by phone did not think that earthquakes happen in Texas, and therefore, they felt that asking Texans questions about earthquakes was a waste of time.[2] So, our final sample may over-represent people who are more sensitive to seismicity risk. Second, this study used mail and telephone in data collection, thus the age of our sample is relatively older (mean age was over 45). Both of these limiting factors constrain generalizability. However, the results are consistent with prior PRISM research across a variety of samples and contexts ([27–30].

Acknowledgements

This research was funded by the Center for Integrated Seismicity Research (CISR) at The University of Texas at Austin. We thank center-funded researchers Cliff Frohlich, who helped select and refine the geographic areas for our survey, and Jon Olson and Peter Hennings, who provided input on technical survey questions.

Appendix A. Survey Items

Construct	Item Wording	*M*	*SD*	*Factor Loading*
Attitude toward Seeking	Using the scale below of 1–5, please indicate whether you feel that seeking information about the potential risks posed by earthquakes is …			
	1. Worthless/Valuable	*3.53*	*1.42*	*.78*
	2. Bad/Good	*3.72*	*1.35*	*.88*
	3. Harmful/Beneficial	*3.85*	*1.30*	*.82*
	4. Unhelpful/helpful	*3.79*	*1.34*	*.86*
	5. Unproductive/productive	*3.50*	*1.41*	*.85*
Seeking Norms	Please read the following statements and indicate your level of agreement or disagreement. Circle one answer for each item. Scale 1–5, strongly agree to strongly disagree			
	1. Most of my close friends who are important to me think that I should seek information about potential risks posed by earthquakes.	*2.36*	*1.11*	*.71*
	2. Most of my family whose opinions I value seek information about potential risks posed by earthquakes.	*2.31*	*1.08*	*.83*
	3. Most of my family expects me to seek information about potential risks posed by earthquakes.	*2.27*	*1.09*	*.82*
	4. Most of my close friends expect me to seek information about potential risks posed by earthquakes.	*2.18*	*1.04*	*.87*
	5. Most people in my community (excluding my family members and close friends) expect me to seek information about potential risks posed by earthquakes.	*2.10*	*0.97*	*.88*
	6. Most people in my community (excluding my family members and close friends) who are important to me think that I should seek information about potential risks posed by earthquakes.	*2.24*	*0.99*	*.76*
	7. The majority of people in my community (excluding my family members and close friends) expect me seek information about potential risks posed by earthquakes.	*2.15*	*0.94*	*.76*
	8. Most people in my community (excluding my family members and close friends) whose opinions I value seek information about potential risks posed by earthquakes.	*2.34*	*0.98*	*.72*
Perceived Behavior Control	Please read the following statements and indicate your level of agreement or disagreement. Scale 1–5, from strongly agree to strongly disagree.			
	1. I know how to search for information about the potential risks posed by earthquakes.	*3.58*	*1.18*	*.72*
	2. When it comes to information about the potential risks posed by earthquakes, I know how to separate fact from fiction.	*3.59*	*1.06*	*.64*
	3. I can readily access information about the potential risks posed by earthquakes.	*3.59*	*1.11*	*.75*
	4. When it comes to finding information about the potential risks posed by earthquakes, I know what to do.	*3.52*	*1.09*	*.82*
Risk Perception	1. Please rate the overall level of risk posed to you by earthquakes. Use a scale of 0–10. 0 = no risk, 10 = high level of risk	*3.07*	*2.71*	*.75*
	2. On a scale of 0–10, how serious are the current risks posed to you personally by earthquakes? 0 = not at all serious, 10 = extremely serious	*2.44*	*2.65*	*.86*
	3. On a scale of 0–10, how likely is it that you will be affected by the risks associated with earthquakes, in the next year. 0 = not at all likely, 10 = extremely likely	*2.12*	*2.48*	*.83*
	4. If you were to be affected by the risks associated with earthquakes in the next year, how severe do you think it would be? 0 = not at all severe, 10 = extremely sever	*2.66*	*2.58*	*.67*
Affect	Using the scale below of 1–5, please indicate how you feel about the potential risks posed by earthquakes:			
	1. Not concerned/Very concerned	*2.63*	*1.39*	*.91*
	2. Not worried/Very worried	*2.40*	*1.32*	*.95*
	3. Not anxious/Very anxious	*2.16*	*1.22*	*.70*
Perceived Knowledge	Rate your knowledge of the potential risks posed by earthquakes on a scale of 0–100, where zero means knowing nothing about the potential risks posed by earthquakes and 100 means knowing everything you could possibly know about the potential risks posed by earthquakes.	*41.33*	*29.62*	-
Insufficency	Think of that same 0–100 scale again. This time, estimate how much knowledge you need to deal adequately with the potential risks posed by earthquakes.	*60.16*	*30.59*	-

[2] This observation is based on 1) notes and phone calls received by the contractor from people who wanted to let him know their thoughts, and 2) calls to 125 randomly selected sample members to assess their interest in participating in the survey.

Seeking Intention	Please read the following statements and indicate your level of agreement or disagreement. Scale 1–5, from strongly agree to strongly disagree.			
	1. I will look for information related to potential risks posed by earthquakes in the near future.	*2.86*	*1.22*	*.86*
	2. I intend to look for information about potential risks posed by earthquakes in the near future.	*2.76*	*1.20*	*.92*
	3. I intend to find more information about potential risks posed by earthquakes soon.	*2.65*	*1.18*	*.95*
	4. I will try to seek information about potential risks posed by earthquakes in the near future.	*2.78*	*1.19*	*.94*
	5. I plan to seek information about potential risks posed by earthquakes in the near future.	*2.72*	*1.18*	*.93*

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2019.101147.

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