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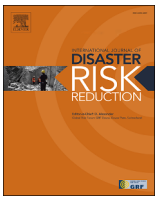

Storm surges: Exploring the role of experience and knowledge

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ABSTRACT

Damaging storm surges from tropical cyclones have not occurred frequently in northern Australia and therefore residents in this region do not have a lot of experience to draw on when assessing potential risk. Lack of experience can also impact on the knowledge an individual holds about an event, and this in turn can alter how associated risks are perceived. This study explored the role of different types of knowledge in perceiving the threat from a storm surge and how experience can impact on these perceptions. The sample consisted of 198 members of the north Queensland community. Participants were asked to indicate the different types of experience they have had with a surge and how knowledgeable they believed they were about these events. Several true/false items gave a measure of objective knowledge, while risk perception was ascertained based on measures of perceived severity, vulnerability, likelihood and potential consequences. The results demonstrated that when an individual had experience with a surge, they were more likely to rely on their subjective knowledge to inform their risk perception. In contrast, when an individual did not have experience, objective knowledge was a better predictor for risk. These findings have implications for how future risk communication can be structured, to ensure individual differences and biases in the processing of risk information are accounted for.

Northern Australia experiences many cyclones, with six on average crossing the coastline each year [1]. With each cyclone, comes the potential for an accompanying storm surge, however, not every cyclone brings a destructive surge. Over the last 100 years, twenty significant storm surge events have impacted the Queensland coastline, with only one resulting in loss of life [2,3]. The surges that have occurred in Australia over this time period have tended to impact sparsely populated areas or have coincided with low or outgoing tides, thereby reducing the damage to human life and infrastructure [4–7]. Due to the infrequency of these events, storm surges are thus classified as low probability, high impact events [8]. That is, they do not occur very often, but they have the potential to bring widespread damage if they do.

Whilst negative consequences from storm surges have generally been avoided in Australia in recent times, this may be about to change. Climate change is not only associated with rising sea levels, but cyclones themselves are expected to be larger and travel further south along the Australian coastline, impacting on regions that have not experienced these events and affecting residents who may not be adequately prepared [9–12]. The likelihood of each cyclone that crosses the coastline being accompanied by a potentially destructive storm surge, is expected to increase [13]. The environmental changes from rising sea levels and increases in sea water temperature are predicted to result in storm surges remaining *high impact* but no longer being *low probability* events [13].

The infrequency of storm surges and the lack of experience with the outcomes of a surge, can influence how an individual perceives the potential danger from these events [14]. When people do not have a lot of experience with a hazard, they can mistakenly

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think they know more about the potential threat than they actually do [15]. Inaccurate perception of risk for an event can then lead to inaccurate perceptions of potential danger [14].

Understanding how individuals perceive and intend to respond to an event like a storm surge is generally examined from a theoretical perspective, such as using the Extended Parallel Process Model (EPPM) [16]. This framework evaluates threat and efficacy perceptions to understand when and why individuals chose to follow the message being conveyed [17]. Emotional reactions and rational considerations of the information being presented are believed to impact on whether an individual chooses to follow recommendations to remain safe. Whilst this model provides an adequate framework for assessing risk communication [18], there does not appear to have been any application of the EPPM or other behavioural models (e.g., the Protection Motivation Theory) in the context of understanding how storm surges are perceived in Australia. That is, there is a lack of research examining the effectiveness of storm surge risk communication within a theoretical framework.

Given the infrequency of storm surges in Australia, the variables influencing how individuals perceive the potential threat from a surge first need to be explored, so that risk communication and behavioural intentions can then be examined from a theoretical perspective. This paper seeks to add to the limited body of research by gaining a broader understanding of the mechanisms that underly how low probability, high impact events are perceived. In particular, this study is interested in the role of different types of knowledge in perceiving the threat from a storm surge and how experience can influence these perceptions.

1. Experience

Prior experience with an extreme event is generally argued to lead to more accurate risk perceptions of similar events [19]. Personal experience can make people aware of their vulnerabilities to the consequences of a disaster and this in turn can translate to protective behaviour [20]. For example, experience with an earthquake has been shown to increase perceptions of the likelihood that another earthquake would occur, reflecting increased perceived vulnerability [21]. Additionally, previous experience with a flood event has been shown to predict engagement in subsequent preparatory behaviours from future flood events [22].

However, the relationship between experience and the accuracy of subsequent risk perception is not always positive [23]. Individuals who experience an event but do not suffer negative consequences or experience personal danger, have been shown to be more likely to *underestimate* the risks from future events [24]. This can lead to a normalisation bias, where individuals are less likely to pay attention to future risk communication [25]. The amount of time that has lapsed since the event can also dimmish how the hazard is perceived, especially if the negative consequences were not severe or the event was not deemed important by those who were at risk of harm [26,27]. The effect of hazard experience on risk perception is believed to be dependent on the individual characteristics of the event as well as how an individual interprets and responds to the situation [28].

Experience with a near-miss event can also alter perceptions of risk [29]. A near-miss event occurs when negative outcomes from an event were expected to occur, but these outcomes did not eventuate [30]. Near-miss experience with a potential hazard can have implications on how future events are perceived, as individuals might wrongly believe that if they were not personally or directly impacted in the past, the event would not pose any danger if experienced again in the future [30].

Furthermore, research in North Queensland has demonstrated that the fringe effects of cyclone experience can influence how the risks associated with future cyclones are perceived [31]. Residents were recruited from two cities that had not been directly impacted by a significant cyclone in recent years but had recently experienced the fringe effects of a category four cyclone. Whilst the cyclone crossed the coast approximately 100 kms away from these cities, fringe effects were still experienced, due to the size of the cyclone. When asked to retrospectively estimate the category of the near-miss cyclone they personally experienced, respondents overestimated the wind speed and underestimated the potential damage from a future significant cyclone. The research found that when individuals do not have an accurate point of reference to base their perception of risk on, the experience they do have can lead to inaccurate risk perceptions [31].

Lack of experience with an extreme event can also lead to misperceptions about potential danger that may occur. For example Meyer et al. [14], researched risk perceptions in an area frequently impacted by tropical cyclones but where significant storm surges had not been recorded in recent years. The researchers found that the wind aspect of an approaching hurricane (i.e., tropical cyclone) was perceived to be more of a threat than the impending storm surge, despite respondents living in a surge evacuation zone. It was suggested that the ease and frequency in which wind damage from prior hurricanes could be recalled increased risk perceptions, whilst the danger from surges, which had occurred less frequently, was harder to conceptualise as a threat [14]. Research in North Queensland has demonstrated that whilst the danger from the wind aspect of cyclones is relatively well understood in this population, the potential danger from accompanying storm surges is underestimated and perceived as less of a threat [32].

Experience is often conceptualised as an all-encompassing variable without giving consideration to different types of experience. For example, a review by Wachinge et al. [19] identified that differentiating between direct and indirect experience could explain variations in subsequent risk perception. Experience can also comprise of emotional dimensions, leading to feelings of worry, uncertainty and helplessness [23,27,33]. Whilst the facets of experience can help to clarify the complex pathway between experiencing an event and risk perception, this becomes more relevant when the audience has a range of experience to draw on. Storm surges have not occurred on a frequent basis in cyclone prone areas of Australia, and therefore it makes sense to ascertain a self-reported perception of experience, as this baseline is what residents use when assessing risk.

The infrequency of storm surges in the region is expected to result in individuals not having sufficient prior experience to inform accurate perception of risk, and this could lead to an underestimation of possible adverse outcomes. Tropical cyclone experience without an associated storm surge, could reinforce the dangers from the wind aspects of these events without highlighting the dangers a surge can bring. Accurate perception of threat for an event that has low probability of occurring but high consequences if it does, is

difficult when uncertainty surrounds the level of associated risks. In communities where storm surges have tended to be near-miss events or impacted on sparsely populated areas, relying on experience to inform risk perceptions does not appear to be an effective way to convey the potential dangers that may occur.

2. Knowledge

According to Graham et al. [34]; it is logical to assume that to perceive a risk, an individual must first know about the potential hazard. Knowledge can then be seen as a positive predictor for accurate risk perceptions. However, research investigating this claim has found mixed results. Whilst some studies have found that greater knowledge can lead to a better understanding of probabilities of an event occurring and potential outcomes [35], others have found the opposite or no relationship [15,36]. But what is sometimes ignored is that there are different types of knowledge. To clarify why knowledge does not always predict accurate risk perceptions, there is a need to differentiate between the domains of objective and subjective knowledge and to explore the conflation of these domains with experience [37,38].

Objective knowledge refers to information based on observations of measurable data and is related to factual information recently acquired or stored in long-term memory [37]. Subjective knowledge, meanwhile, is an interpretation of what people *think* they know and reflects a level of confidence in self-rated knowledge [37]. Low levels of subjective knowledge may result in the search and validation of additional information, while high confidence in one's subjective knowledge could lead to a reliance on pre-existing information that may or may not be accurate [37]. When an individual does not have pre-existing objective knowledge about an event, they tend to rely on their subjective interpretation, which can lead to inaccurate perceptions about the threatening situation and potential consequences [39,40]. This demonstrates the not unsurprising disconnect between what people think they know and what they actually know [41].

Subjective knowledge is generally influenced by experience, but this does not always translate to accurate risk perceptions, as highlighted in the previous section. When an individual is unfamiliar with or lacks factual information about an event, they make assumptions or intuitive judgments based on what they know, otherwise known as using a heuristic or 'rule of thumb' [42,43]. Inaccurate beliefs about a potential threat can result in biases in the perception of risk and not only impact on the performance of subsequent protective behaviour but can also be difficult to change [44]. High confidence in perceived subjective knowledge is associated with individuals being less likely to seek out new information [41]. This overconfidence is also known to be associated with confirmation bias where, when encountering new information, individuals are more likely to attend to information congruent with their pre-existing beliefs than information that is contradictory [45]. Both these processes have the effect of solidifying an individual's perception that their opinion is correct [46].

When an individual lacks adequate experience with an event, their reliance on subjective knowledge increases [39]. If they have not previously experienced damage or have near-miss or fringe experience, an individual may have higher confidence about their risk perception accuracy and mistakenly perceive the threat to be less than what it is. Additionally, they may be less likely to pay attention to risk communication or be willing to change their perceptions of associated risks. This becomes a concern when risk communication aims to increase general knowledge about an event, such as a storm surge, without giving consideration to the parts of the message that is attended to or how this information might be interpreted.

The inconsistent relationship between knowledge and risk perception appears to be explained by the distinction between the objective and subjective domains [38]. Objective and subjective knowledge tend to be moderately to strongly correlated ($r = 0.30–0.60$), however, they are far from being perfectly correlated, suggesting they measure different dimensions of knowledge [37]. Whilst the domains of knowledge are often collapsed under the one variable, it is important to make the distinction between the objective and subjective domains, as they each have a different effect on information processing and subsequent behaviour [47]. Knowledge can comprise further dimensions, however, the main purpose of this study, is to examine the difference between what an individual perceives they know and what they actually know.

The aim of this paper is to explore how different levels and types of experience and knowledge affect the perception of threat associated with storm surges. As discussed, different types of experience can have varying effects on how the risks associated with storm surges are perceived. Subjective and objective domains of knowledge have been shown to influence risk perception in different ways and experience is expected to affect these relationships. Based on this, the following hypotheses are proposed:

H1. Experience with a storm surge is not expected be a significant predictor of perceived risk. Furthermore, experience with a storm surge that did not also include experiencing negative consequences is expected to lead to an underestimation of potential risk.

H2. Experience is expected to have a positive relationship with both subjective and objective knowledge, which in turn are both expected to predict risk perception.

H3. The relationships between the types of knowledge and risk perception will differ depending on whether participants had experience or not. Objective knowledge is expected to predict risk perception regardless of experience, while subjective knowledge is only expected to predict risk perception for those with experience.

Understanding the relationships between the domains of knowledge and risk perception, will enable the development of risk communication that accounts for these differences, regardless of experience or lack thereof. The target population has limited experience with storm surges and so it is important to explore the role of knowledge in perceiving risk, so that future communication does not reinforce inaccurate beliefs, but rather increases retention of accurate information about potential danger. These findings are expected

to contribute to the greater academic discussion around communicating the risks from low probability, high impact events and lead to the application of a theoretical framework in evaluating how messages are conveyed.

3. Method

An online survey was selected as the optimal way to obtain information from community members regarding their understanding and perceptions of storm surges and associated risks. Self-administered surveys are an effective way to collect data from a wide range of participants to ensure the information is representative of the targeted population [48].

3.1. Participants

The survey was made available to community members living throughout the North Queensland region, Australia, via the social media platforms of Facebook and Twitter and distributed through community groups. People who lived throughout the Townsville area and surrounds (i.e., from Mackay north to Cairns) were able to respond. A community sample of 230 participants was initially recruited.

Respondents were asked to report their age, gender, postcode at their residential address, how long they have lived at that postcode and their current household status. Data was only included in the final analysis if the participant had completed more than 85% of the questionnaire, which resulted in 32 participants being excluded. The final sample consisted of 198 participants (72% female). The average age of respondents was 35 years with a standard deviation of 16.2 years and range of 17–74 years. The average number of years living in their current postcode was 9.5 years with a standard deviation of 8.7 years and a range of 0–44 years. Most frequently, respondents reported that they lived in their own home (42%), followed by renting (31%), live with parents (20%) and other (7%). The majority of respondents reported their home address as being in the Townsville region ($N = 160$), followed by the Cairns region ($N = 16$) and from the area including Lucinda and Mission Beach ($N = 11$), which had both been directly hit by Cyclone Yasi in 2011. The remaining participants recorded their home address as located south of these areas ($N = 11$).

3.2. Measures

3.2.1. Experience

Participants were asked to indicate if they had ever experienced a storm surge while living in the region (Yes/No) and the number of storm surges experienced (0, 1–5, 6–10, more than 10). Participants were also asked if they had experienced negative consequences from a storm surge including property damage, personal injury or prior evacuation (Yes/No).

3.2.2. Subjective knowledge

Subjective knowledge was ascertained by asking participants “How knowledgeable do you think you are about storm surges”, along a ten-point Likert scale ranging from 1 (not at all knowledgeable) to 10 (extremely knowledgeable). This item was presented to prior to the questions regarding objective knowledge, to avoid any biases in the subjective interpretation of what individuals perceived their knowledge to be.

3.2.3. Objective knowledge

Participants were asked to respond True, False or Don't Know to thirteen randomly presented questions about storm surges. This item included statements such as “A storm surge is the same as a tsunami” and “Storm surges only occur with tropical cyclones”. These questions were formulated from information regarding storm surges on the Australian Government website (see Ref. [49] and were presented after the items to ascertain *Perceived Strom Surge Risk* to avoid impacting on the perception of threat. Correct answers were assigned a value of one, with the total correct responses generating a measure of objective knowledge.

3.3. Threat variables

Risk perception was operationalised in a similar manner to past research [50]. *Perceived storm surge risk* was assessed based on participants' responses to four items: (1) how severe do you perceive a significant storm surge would be if one occurred in the city where you live; (2) how vulnerable would you feel about a significant storm surge if one occurred in the city where you live; (3) how likely do you think it is that a significant storm surge would occur in the city where you live; and (4) how significant do you think the negative consequences could be if a significant storm surge occurred in the city where you live. Each item was rated on a five-point scale from 1 (not at all) to 5 (extremely). Missing values were replaced with the mean of each item. *Perceived storm surge risk* was created by averaging the summed scores across the four subscales, with higher scores indicating a greater perception of risk. The resulting measure had an acceptable Cronbach's Alpha of $\alpha = 0.735$.

3.4. Procedure

Ethical approval was obtained through the James Cook University Human Research Ethics Committee (#H8224). A Facebook page was created for the study, which had a link to the survey and some additional information. A link to the survey and Facebook page was posted in several relevant Facebooks groups in the region. Links were posted to weather groups (e.g., Oz Cyclone Chasers), disaster information groups (e.g., North Queensland Disaster Watch) and community notice boards (e.g., Townsville Community Noticeboard). The survey was made available online using the Qualtrics platform from February 2021 until June 2021. No cyclones or storm surges directly impacted on the region during this time. The survey took approximately 15 min to complete and informed consent was obtained prior to the questionnaire being made available to view.

4. Results

Table 1 shows that 43% of participants reported having experience with a storm surge. However, very few had experienced negative consequences with only 23 respondents reporting property damage and only 10 indicating prior evacuation. No respondents reported having experienced personal injury from a storm surge. The number of storm surges experienced can be seen in Table 2. Of the respondents who had experienced a storm surge, the majority had experienced between one and five events.

The average score on the subjective knowledge scale ranging from one to ten was 4.24 ($SD = 2.19$). The average score on the objective knowledge scale for correct responses out of the possible 13 answers was 7.66 ($SD = 2.62$). A Pearson's product-moment correlation was run to examine the relationship between objective and subjective knowledge and a moderate significant association was found ($r = .363$, $p < .001$).

The average score on the *perceived storm surge risk* measure was 3.52 ($SD = 0.70$) out of a possible score of five.

4.1. Hypothesis 1

A point-biserial correlation was run to examine the relationship between participants' overall indication of whether they had experienced a storm surge or not (dichotomous) and perceived storm surge risk (continuous). As can be seen in Table 3, no significant association was seen ($r_{(pb)} = -.104$, $p = .143$).

A frequency distribution was run to identify the participants who had experience with a storm surge but *had not* experienced negative consequences, including property damage, personal injury or prior evacuation. Sixty participants (30%) met these criteria. A new variable was computed, separating these participants from the rest of the sample. A point-biserial correlation was then conducted to look at the relationship between participants who had experience with a storm surge but had not experienced any negative consequences and how they perceived the storm surge risk. As can be seen in Table 3, a weak but significant, negative correlation was found ($r_{(pb)} = -.154$, $p = .030$).

4.2. Hypothesis 2

A point-biserial correlation was run to examine the relationship between experiencing a storm surge and objective knowledge and a weak significant association was seen ($r_{(pb)} = .140$, $p = .050$; see Table 3). A Pearson's product-moment correlation examined the relationship between objective knowledge and perception of risk and a significant, positive relationship was seen ($r = .245$, $p < .001$).

A point bi-serial correlation was run to examine the relationship between experiencing a storm surge and subjective knowledge and a weak significant association was seen ($r_{(pb)} = .151$, $p = .033$; see Table 3). A Pearson's product-moment correlation examined the relationship between subjective knowledge and perception of risk and a significant, positive relationship was seen ($r = .210$, $p = .003$).

Table 1
Percentage of participants responding 'yes' in each category (more than one answer possible).

Categories	Storm surge	
	N	%
Experience	85	42.9
Property Damage	23	11.6
Personal Injury	0	0
Prior evacuation	10	5.1

Table 2
Number of storm surges experienced.

Number of Storm Surges	N	%
0	113	57.6
1–5	82	40.9
6–10	2	1.0
More than 10	1	.5

Table 3
Correlations of experience and negative consequences, and risk perception.

Variables	1.	2.	3.	4.	5.
1. Experience	–				
2. Subjective know	.151*	–			
3. Objective know	.140*	.363**	–		
4. Perceived Risk	–.104	.210**	.245**	–	
5. Experience but no negative consequences	–	.088	.056	–.154*	–

*$p < .05$. **$p < .01$.

4.3. Hypothesis 3

A multiple regression analysis was conducted to examine if objective knowledge and subjective knowledge could predict participant's perceived storm surge risk. The results of the initial regression indicated that the two predictors explained 7.7% of the variance ($F_{(2,195)} = 8.12$, $p < .001$). When subjective knowledge was held constant, it was found that objective knowledge significantly predicted perceived storm surge risk ($\beta = 0.052$, $p = .009$). However, when objective knowledge was held constant, subjective knowledge no longer predicted perceived storm surge risk ($\beta = 0.045$, $p = .061$).

The subsequent regressions examined if the relationships between the domains of knowledge and risk perception differed depending on whether the participant had experience with a storm surge or not. The first regression analysed those who did not have experience with a storm surge, and demonstrated that objective and subjective knowledge explained 10.9% of the variance ($F_{(2,110)} = 6.71$, $p = .002$). Whilst objective knowledge was found to be a significant predictor ($\beta = 0.096$, $p < .001$), subjective knowledge was not ($\beta = -0.020$, $p = .522$). The final regression looked at those who had experience with a storm surge and demonstrated that objective and subjective knowledge explained 23.8% of the variance ($F_{(2,82)} = 12.78$, $p < .001$). In this model, subjective knowledge was found to be a significant predictor ($\beta = 0.155$, $p < .001$), while objective knowledge was not ($\beta = 0.001$, $p = .960$). Objective knowledge was found to be a predictor of storm surge risk when participants did not have experience, however, when they did have experience, subjective knowledge was shown to be a significant predictor.

5. Discussion

The focus of this study was to investigate the role of experience and knowledge in understanding how storm surges from tropical cyclones are perceived in a north Australian population. Storm surges have the potential to cause damage to lives and infrastructure within this region [5,14] but because significant damaging surges have not occurred in recent times, it is unclear how these events are perceived. It is important to consider how and why people perceive potential danger storm surges can bring, so this can be addressed in the way information about these events is conveyed.

5.1. Experience

Experience with an event can be a significant predictor for how future events are perceived [19]. However, the target region has only been impacted by minimal significant storm surges in recent times and therefore it was unclear what role experience would have on risk perception. The results demonstrated that less than half of the sample had experienced a storm surge and only a very few reported having negative experiences with these events. It was therefore not surprising that experience alone did not have a relationship with how participants rated their perception of risk, supporting part of the first hypothesis.

When a further correlation was conducted between the participants who had experienced a storm surge but did not experience any negative consequences, and how they perceived potential risks from a storm surge, a weak negative relationship was found. These findings somewhat support the hypothesis, suggesting that type of experience could be an important factor in determining whether this variable impacts on perceived risk. As noted by Bronfman et al. [23]; experience does not just comprise physical or material experience but also emotional dimensions that reflect a level of perceived fear of the event and associated consequences. Experience with a storm surge that did not cause damage and thereby lead to an emotional response, may result in individuals underestimating potential danger. Near-miss experience or experience with the fringe effects of a cyclone can further reinforce the misperception of risk [30,31]. Individuals who have experienced an event without any direct impact may be more likely to think they are not vulnerable to future events.

However, it must be noted that the relationship between experience but without negative consequences and perception of risk was only very weak. Strong evidence was not found for the claim that individuals with this type of experience would underestimate potential danger. Based on these findings, there appears to be a lack of clarity surrounding the role of experience and further investigation is warranted. These findings are also better understood when the role of knowledge is considered.

5.2. Knowledge

A positive relationship was found between experience and the domains of knowledge, in that the more experience an individual had with a storm surge, the higher they scored on the objective knowledge measure and the higher they rated their subjective knowledge. This was not a surprising finding as it makes sense that experience will lead to an increase in what an individual knows about an event and in having confidence in what they know. The domains of knowledge in turn were related to risk perception, supporting the second hypothesis. Given that experience alone was not enough to predict risk perception, these findings highlight the necessity to further explore the effects of objective and subjective knowledge in understanding how the danger from potential storms surges is perceived.

The third hypothesis predicted that whilst objective and subjective knowledge would each affect risk perception, these relationships would differ depending on a participant having experienced a storm surge. This hypothesis was somewhat supported. Objective knowledge was shown to predict risk perception, regardless of the influence of subjective knowledge, reaffirming that the more an individual knew about storm surges, the more they were likely to accurately predict how serious these events could be. Subjective knowledge, however, was not shown to predict perceived risk when objective knowledge was held constant. It appeared that subjective knowledge in and of itself was not being used to inform risk.

When the analysis looked at the differences between the individuals who did and did not have experience, those who did not have experience with a storm surge reported similarities to the sample as a whole. That is, objective knowledge was a good predictor for risk perception, while subjective knowledge was not contributing to how associated risks were perceived. When individuals did not

have a point of reference, it appeared they sought out information to inform their risk perception, supporting that objective knowledge was a better predictor than subjective knowledge in this instance.

The results for the participants who had experience, however, showed opposite outcomes compared to those who did not have experience. In this analysis, subjective knowledge was found to be a significant predictor when objective knowledge was held constant. It appears that individuals who had a point of reference could draw on this personal experience to inform their knowledge base and this translated to their perception of risk. Conversely, objective knowledge was not a significant predictor when subjective knowledge was held constant. These findings somewhat supported the hypotheses. Subjective knowledge was expected to predict risk perception for participants who had experience, regardless of objective knowledge, and this was demonstrated.

However, it was surprising that objective knowledge did not continue to be a significant predictor for the participants who had experience. It could be suggested that the type of experience sustained led to a normalisation bias [51], where participants relied on their earlier non-eventful experience as a point of reference. Less than half the sample (43%) reported experience with a storm surge and even less (17%) indicated they had experienced negative consequences (property damage, personal injury or prior evacuation). As noted earlier, experience alone did not have a relationship with risk perception. It appears the experience that was recorded, impacted on the ability for objective knowledge to predict risk perception, and instead reinforced pre-existing, inaccurate information about storm surges [39,40]. When an individual has high confidence in what they think they know, they are unlikely to seek out external stimuli to prove otherwise and more likely to rely on heuristics to make sense of new information [37,46]. This appeared to be reflected in the disconnect and dissonance between objective knowledge and risk perception, for the participants who had experience.

Several limitations were identified in the study. Firstly, relevant social media and community groups were utilised for recruitment and therefore participants potentially already had an interest in cyclone and storm surge research. Whilst this may have impacted on self-rated knowledge, it was not expected to change the number of storm surges that people perceived to have experienced or perception of threat. The focus of this study was how perceived experience can influence the relationship between knowledge and risk perception and so this limitation should not affect the findings from the study.

Secondly, it is acknowledged that the measure experience did not encapsulate all facets of this variable. Unlike past research that has considered direct, indirect, life and vicarious experience [52] or emotional dimensions [23], this study used only a measure of direct experience, along with sub-components of experiencing property damage, personal injury and prior evacuation. Given that storm surges have not occurred frequently in the target area, it made more sense to get an overall indication of experience. Future research could expand on the facets of experience, which may become more relevant as the region starts to experience storm surges on a regular basis. Additionally, an indication of experience could be nuanced to include experience with a storm surge within a set time period, to take into account the effect of time on the influence of experience.

Furthermore, the concept of knowledge was limited to the distinction of subjective and objective domains without considering other forms of knowledge that can inform what someone knows about an event. Whilst the underlying contributory factors of knowledge are complex, the aim of this study was to differentiate between what someone perceives they know about a storm surge and what they actually know. The domains of knowledge could be explored in future research to further understand how other types of knowledge inform risk perception about storm surges. Both of these recommendations could better assess the influence of experience and knowledge on risk perception.

Lastly, self-reported measures can be influenced by social desirability and a tendency to overestimate responses [53]. Given that minimal storm surges have occurred in recent times, it is unclear if the respondents' estimates of experience with a storm surge were accurate. Whilst Severe Tropical Cyclone Yasi crossed the coastline in 2011 and brought a significant storm surge to the region, the damage sustained was mainly concentrated around the Tully Heads and Cardwell region [4]. There were eleven participants who indicated living in this region, however, the majority ($N = 160$) reported their home address as within the city of Townsville, which was only impacted by the fringe effects of this cyclone. It could therefore be assumed that the self-reported indication of experience with a storm surge reflected a measure of indirect experience, and this could have led to an overestimation of experience.

6. Conclusion

Storm surges have the potential to bring widespread damage to the north Australian region, however, the infrequency of previous events appears to have impacted on how possible danger is perceived. This study demonstrated that experience can both facilitate and impede risk perception, and furthermore, impact on the causal pathway that knowledge has in predicting risk. Given that individuals who had experience were more likely to rely on subjective knowledge when assessing risk, it could be suggested that these individuals would benefit from tailored communication that emphasises personal risk and impact of events. Likewise, individuals without experience were more likely to seek out objective knowledge and so focusing on what they can do to prepare and respond to an event rather than emphasising risk, may be a better approach. Future research should focus on the development of messages that account for these biases in processing information, to ensure risk communication motivates individuals to pay attention and follow recommendations.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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