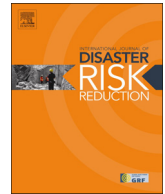




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The influence of impact-based severe weather warnings on risk perceptions and intended protective actions

Sally H. Potter^{a,*}, Peter V. Kreft^b, Petar Milojev^c, Chris Noble^b, Burrell Montz^d,
Amandine Dhellemmes^a, Richard J. Woods^a, Sarah Gauden-Ing^e

^a GNS Science, 1 Fairway Drive, Avalon, Lower Hutt 5010, New Zealand

^b MetService, 30 Salamanca Road, Kelburn, Wellington 6012, New Zealand

^c College of Humanities & Social Sciences, Massey University, Private Bag 102904, North Shore, Auckland 0745, New Zealand

^d East Carolina University, Greenville, NC 27858, USA

^e Wellington Region Emergency Management Office, 2 Turnbull St, Wellington 6142, New Zealand

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ABSTRACT

This paper presents the results of an online survey of the New Zealand public ($n = 1364$), conducted in 2015, that tested the influence of impact-based severe weather warnings on risk perceptions and intended protective actions. We used a hypothetical severe weather event involving strong winds, with 50% of participants receiving an impact-based warning, and 50% receiving a more traditional phenomenon-based warning (which in this case is when the wind speed is expected to be higher than a given number).

Our results indicate that impact-based warnings may be more effective than phenomenon-based warnings in influencing the recipient's perception of the hazardous event (their sense of threat, concern, and understanding of the potential impacts), but this does not translate to a higher level of action. Characteristics of gender, age, and location of residence were also influences on risk perceptions and intended actions. However, experience with having been affected by strong winds in the past was not a strong influence on intending to respond. Our findings support the inclusion of information about hazards, impacts, and 'what to do' information in a warning message.

1. Introduction

Globally, significant damage and casualties result from hydro-meteorological events every year, despite many of these events being well forecast, and warnings being issued. The World Meteorological Organization [46] describes this to be the result of a perceived gap between the forecasts and an understanding of the potential impacts by responding agencies and the public. Traditionally, National Meteorological Services have issued phenomenon-based weather warnings based on fixed criteria (for example, when the wind speed is expected to be higher than a given number) regardless of the expected effects of the event. WMO advocates for a more comprehensive warning system, which links weather modelling and forecasts to hazards and impacts. Impact-based warnings use flexible thresholds to trigger the issuance of a warning. The thresholds vary in space and time to reflect changing exposure and vulnerabilities [46]. For example, an impact-based severe weather warning for strong wind might be issued in one city, but not another for an identical event, if the second city was known to be more resilient to such events. This system requires an integrated, multi-

disciplinary and multi-hazard approach [46]. Such an impact-based forecast and warning system is supported by the Implementation Plan for the WMO Strategy for Service Delivery, adopted in 2013 (cited in [46]). However, very little research has been conducted on the efficacy of impact-based warnings.

The Meteorological Service of New Zealand Ltd. (MetService) issues severe weather warnings for New Zealand. Prior to the development and implementation of an impact-based weather warning system for New Zealand, MetService expressed a desire for research to be conducted to investigate the effectiveness of such a system in a New Zealand context. The research was conducted in collaboration with GNS Science and Massey University with input by social scientists, meteorologists, and end-users, including from the Wellington Regional Emergency Management Office (WREMO). A data report of the results of this survey has been published by Potter et al. [31]. This paper describes and discusses those results.

* Corresponding author.

E-mail address: S.potter@gns.cri.nz (S.H. Potter).

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1.1. Literature review and research hypotheses

A warning system should “empower individuals, communities, and businesses to respond to hazards in a timely and appropriate manner that will reduce the risk of death, injury, property loss, and damage” ([35], p. 74). Prompting actions in response to a warning is fundamental to the design of an effective warning system. Perceived challenges of warning systems include that the local, regional and national governmental organisations, as well as the public, often do not understand what the impacts of severe weather and storm surge will be. This was noted following both Hurricane Ike [20] and Hurricane Sandy [35] in the US, prompting a call for more studies on people’s interpretation and use of severe weather warnings. Risk perceptions of the public have been found to relate to taking protective actions (e.g., [26,1,6,13,23]). As described by Peacock et al. [24], it should be recognised that public and scientific risk perceptions may differ due to social and cultural contexts; and research on risk perceptions differ in terms of what is measured. Research has shown that people are more likely to believe and respond to a warning if they understand the warning [19], and are knowledgeable about the hazard (e.g., [33]) and potential impacts (discussed further by [26,20]). In a review of research about 12 hurricanes in the US, Baker [1] found that residents’ knowledge about the hazard is only weakly related to evacuating, but knowledge about potential impacts at a personal level is a strong influence on evacuating. In 2008, Morss and Hayden [20] interviewed residents in Galveston, US, who had recently been affected by Hurricane Ike. They found that evacuation planning and preparations began prior to the official call for evacuations, highlighting the importance for warnings to include information on the storm forecast, potential impacts, and recommended actions. They also found that residents prepared for strong winds, but not flooding associated with storm surge, due to lack of risk perception and knowledge about that peril. Our first research hypothesis (RH) investigates the role of the impact-based warning in helping receivers to understand the consequences of a hypothetical strong wind event.

RH1. *The participants find it easier to understand the effects of the hazard if they receive an impact-based warning in comparison to receiving a phenomenon-based warning.*

People make decisions about protective actions according to the level of threat that they perceive from the hazard, provided they believe that protective actions will be effective at mitigating the hazard (‘response efficacy’), and they are capable of undertaking the protective action (‘self-efficacy’; e.g., [36,2,17,26,28]). For example, hurricane-affected residents in the US were found to be more likely to evacuate if they believed that the winds would be strong enough to cause damage, or would cause flooding to their property; i.e. were seen as being threatening [1]. The downgrading of Hurricane Irene in the US, 2011, was perceived by members of the public to indicate that the level of risk had decreased [21]. These authors suggested emphasising impacts in messaging to maintain higher risk perceptions, and prompt an appropriate response. Ripberger et al. [33] found that US participants receiving hypothetical tornado warnings were more likely to take some sort of protective action as tornado impact descriptions increased in severity. We tested which type of warning influences the level of threat perceived by the New Zealand participants:

RH2. *The participants believe the hazard to be more threatening when they receive an impact-based warning than a phenomenon-based warning.*

Credibility of official warnings has been found by some [11,32], but not all [25,38] researchers to be an influencing factor in prompting response actions. In perhaps the only previous study that tested impact-based warnings and credibility, Perreault et al. [25] found that regular warning messages (without impact information) were seen as more credible than the new ‘scary’ messages (with impact information) for

tornadoes in the US. We tested to see whether this finding was valid with New Zealand participants. In support of the findings by Perreault et al. [25], we predict that:

RH3. *The participants believe the message to be more credible when they receive a phenomenon-based warning than an impact-based warning.*

Fear appeals can cause receivers of the message to be concerned about a hazard by describing the impacts on them should they not follow recommended courses of action [44]. They are persuasive messages that intend to “scare people” and prompt actions, to reduce the impacts of the hazard ([44], p. 329). In fear appeal messages, the recommended action must be perceived as being effective in reducing the risk, and the receiver must believe that they are capable of performing the action [44]. Increased fear can lead to an intended behavioural response (e.g., [42]). Based on these prior findings, we suspected that warnings that describe impacts will arouse more concern, and therefore may lead to more actions. We investigate whether impact-based warnings are more likely to promote a level of concern in a New Zealand context:

RH4. *The participants are more concerned about the hazard when they receive an impact-based warning than a phenomenon-based warning.*

The overall purpose of warnings is to achieve an appropriate and timely response to mitigate the risk. Appropriate responses to a hypothetical strong wind event (described further in the methods section) would include securing loose items on one’s property, driving carefully, and considering alternative transport options (because, for example, driving a motorbike or high-sided vehicle may be more vulnerable to wind-related impacts). Searching for additional information is also a common response to receiving warning information. In this research, we wish to understand the benefits of impact-based warnings in comparison to phenomenon-based warnings. We undertake this research in an experimental, hypothetical environment to allow for a clear distinction between the two types of messages and the outcomes, which are intended responses. The intention to respond to information has been found to correlate to actual responses (e.g., as reviewed by [43]). Given the previously-discussed findings from research that increased perceptions of threat, concern, credibility, and an understanding of impacts can increase the likelihood of a behavioural response, we hypothesise that:

RH5. *Impact-based warnings are more effective at prompting the public to intend to take protective actions than phenomenon-based warnings.*

In addition to the influence of warning characteristics, factors including receiver characteristics and prior experience influence the decision to respond (e.g., [16]). Previous direct experience as an influence on how people react to warnings with similar events has had mixed results in past studies, with some researchers finding that a higher level of experience is related to increased protective behaviours [20,22,26,39] and others finding little to no influence [1,11,14]. Demuth et al. [8] found in a study of the influence of people’s past experiences with hurricanes on evacuations during future events that some processes, including past experience with evacuation and financial loss, can increase evacuation intentions, while others (such as past emotional impacts from hurricanes) can cause decreased evacuation intentions. The influence of experience on the intention to respond is not a primary focus of this research, so we keep our hypothesis at a fairly broad level:

RH6. *Participants who have previously been affected by strong wind events are more likely to intend to respond.*

Demographic factors such as socioeconomic status, age, and gender have also been found to influence the processing of information and responding [16]. Females are more likely to respond to warnings than

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