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Preparing for the new normal: Students and earthquake hazard adjustments in Oklahoma

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ABSTRACT

Since 2010, Oklahoma has seen a major increase in earthquakes, with an average of one-to-two M3.0 earthquakes occurring per day in 2015. We know little, however, about resident's risk perceptions regarding this new hazard. This study examines how individual risk perceptions, hazard experience, hazard salience, and other factors influence individual hazard adjustments efforts. We find that risk perceptions are related to an individual's intention to adopt hazard adjustments, but not the actual adoption of adjustments. Hazard salience is related to actual adoption of hazard adjustments, as are several demographic variables. We also find that individuals are more likely to make hazard adjustments for earthquakes if they believe those adjustments will also protect them from other hazards, such as high wind events. This leads us to make some practical suggestions for emergency managers regarding educating citizens about the actual risks associated with earthquakes and the value of individual mitigation efforts.

1. Introduction

Much of what we know about earthquake hazard adjustment has come from research in geographical regions that have been prone to earthquakes for decades (i.e. California, Japan, New Zealand). Residents in these areas are generally aware of their earthquake risks and know their protective action options [32,39]. Oklahoma has seen an exponential increase in earthquake activity since 2010. While the state experienced less than one or two earthquakes above M3.0 on average per year from 1978 to 2008, by 2015 portions of the state were experiencing one to two earthquakes of M3.0 or greater every day [50]. According to a report issued by the Oklahoma Geological Survey, the volume of the oil industry's waste-water injection wells and earthquake frequency are following the same tendency [8]. Thus the frequency of these earthquakes are likely tied to waste water injection activities, which are a by-product of drilling for oil and gas in Oklahoma. Although most of the earthquakes are relatively small, a few have caused considerable structural damage to both homes and businesses [24,52]. This is unsurprising as most buildings in Oklahoma were built to prevent wind damage or flooding losses. The USGS forecast for damage from earthquakes in 2017 shows that the north central region of Oklahoma has a 5–12% chance of experiencing property damage from earthquakes [8]. We have little information about how individuals in Oklahoma perceive earthquake risks and how they are adjusting to the new earthquake hazard, including mitigation and preparedness activities. This research will begin to address these issues, exploring how individuals understand this relatively new risk and what they are, or are not, doing to address that risk.

When hazards challenge us to reconsider the safety measures we rely on, key stakeholders in communities must adapt, make compromises, and address risks to reduce community vulnerability [53]. While there are a number of activities and projects government can undertake to reduce risk (fault and liquefaction hazard mapping, protection of critical infrastructure, etc.), households carry much of the burden for addressing risks. Hazard adjustments, for example, are an important household activity to reduce the risk of a hazard before it occurs [38]. As such, hazard adjustments encompass both mitigation (sustained actions that passively reduce the long-term risk to people or property) and preparedness (actions that enable or increase capacity to respond to an event) activities [66]. In the case of earthquake hazards, mitigation measures would include activities such as strapping water heaters, tall furniture, and heavy objects to the wall, installing earthquake latches to keep cabinets securely closed, and purchasing insurance, whereas preparedness measures would include activities such as storing emergency supplies at the home, learning how to shut off water, gas, and electric utilities, and developing a household earthquake plan [27,28,48]. Understanding why individuals choose to adopt or not adopt hazard adjustment measures is important to understand because hazard adjustment can lower households' hazard exposure level, physical and social vulnerability, and minimize the physical and social impacts of hazards

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[37]. Given the potential risks associated with earthquakes in Oklahoma, it is important to develop an understanding of how individuals decide whether to adopt any of these mitigation measures available to them.

In this paper, we address hazard adjustment related to earthquakes largely by replicating a 2000 study by Lindell and Whitney that focused on hazard adjustment to earthquake risk in Southern California. Since Lindell and Whitney's study was done 17 years ago, we modified some earthquake adjustment questions to accommodate a more modern context. In addition, we included questions that address Oklahoma residents' view on engaging political and non-profit organizations' earthquake awareness activities. Like Lindell and Whitney, we use a sample of university students in the middle of the geographic region most likely to experience earthquakes in Oklahoma. Although our sample does not reflect the general population in Oklahoma, the data does provide insights on younger generation's views of this newly introduced earthquake risk. Given that, this research contributes to the literature by extending the existing research on hazard adjustment to a new area with an emerging earthquake risk with an oft avoided population.

2. Literature review

Research on hazard adjustment and individual decisions to take part in mitigation activities has led to a number of theories, including the Theory of Reasoned Action (TRA) [15,16], the Theory of Planned Behavior (TPB) [1], and the Person-Relative-to-Event Theory (PrE) [47]. Much of this research stems from the field of cognitive psychology and the decision-making literature, and findings suggest that multiple factors influence individual decisions to act, including demographics, exposure and experience with hazards, and other psychological factors. A mix of these variables often influences risk perception, which impacts hazard adjustment decisions.

These theories have led to a number of important insights in our understanding of why individuals choose to adopt or not adopt mitigation measures. For this study, we are focusing primarily on one model that explains individual and households' disaster protective action decision making: The Protective Action Decision Model (PADM). The PADM illustrates how individuals and households respond to or prepare for disasters [33,35,36]. This model focuses on hazard information flow and individual perceptions of stakeholders (government organization, news media, etc.), protective action/hazard adjustment measures, and threat characteristics. According to the PADM, information received by individuals first passes through a pre-decisional process, and is then internalized. Once internalized, that person will make protective action decisions based on their perceptions. Specifically, PADM suggests that hazard information will not directly make individuals take necessary actions to protect themselves against hazards [35]. The perceptions of risk, stakeholders, and protective actions/preparedness measures will affect the ways in which individuals adopt protective actions or preparedness activities.

This model is particularly relevant to this work because PADM proposes causal mechanisms that shape adoption intentions and decisions to adopt hazard adjustments. The PADM has been used to explain the ways in which individuals make protective action decisions during disasters such as hurricane or floods; however, it is important to note that the application of PADM is not just for disaster response studies. Lindell and Perry [35] indicated that PADM can also be applied to studies that focus on other disaster phases such as mitigation and preparedness. Therefore, this study uses the PADM framework to structure our discussion of the relevant literature. Based on this model, there are three major psychological factors that could directly affect the decision to adopt hazard adjustment activities. These include risk perceptions, perceived efficacy of adjustments, and perceptions of stakeholders, such as government, media and nonprofit organizations. In addition, other individual characteristics, such as hazard experience and demographic characteristics could also influence hazard adjustments, because these factors affect how individuals perceive the psychological factors. We review the articles that address these factors below.

2.1. Psychological factors

2.1.1. Risk perceptions

Risk perceptions are one of the most common factors previous research highlights as influencing hazard adjustments and disaster response (e.g. [22,73,76]). A number of studies found a positive relationship between risk perceptions and hazard adjustments [11,21,31,34,6,61,67]; however, other studies find less evidence of a relationship between risk perception and hazard adjustment. Lindell and Prater [29] found that perceived risk only had a moderate correlation with hazard adjustment adoption [38,71]. Other studies found nonsignificant relationships between risk perception and adoption intention or actual adoption [29,38,57,71,72].

As the concept of risk is multidimensional, so are the findings regarding this relationship. Studies often measure risk as the relationship between the probability of occurrence and the potential impacts of an event, parsing risk out to property and to health. Lindell and Whitney [38] found that college students in an earthquake-prone area in California suggested that risk to property is greater than risk to their own personal health. This is important to note because a number of studies have found that as belief in risk to individual personal health increased, likelihood of individual hazard adjustments also increased [7,70]. In a similar but slightly different finding, Duval and Mulilis [12] found that respondents who thought the potential earthquake magnitude was higher were more likely to adopt adjustments. In addition, Axelrod, Mcdaniels, and Slovic [5] found that individuals perceived the risk associated with natural and technological hazards quite differently: they saw technological hazards as being associated with activities that offer potential benefits to society and which can be regulated by government, and therefore perceived these activities as relatively low risk. Västfjäll, Peters, and Slovic [69], in contrast, found that individuals saw natural hazards as uncontrollable, high risk, and without any real benefit. This is critical because, as found by Fischhoff et al. [14], individuals are willing to accept higher risk levels associated with activities they find more beneficial. Finally, Sjoberg [65] found that support for hazard adjustments was linked to perceived severity of consequences, but not likelihood of harm. These findings suggest that risk perceptions are associated with protective action decisions but that the association is not clear.

2.1.2. Hazard adjustments activity perceptions

Beyond the focus on individual perception of hazards, many existing theories and models note the role of an individual's perception of potential adjustments. The TRA, for example, suggests that an individual's perception of a possible mitigation action is more predictive of their likelihood to adopt hazard adjustment measures than their perception of the likelihood and potential severity of a given hazard [16]. The PrE, in comparison, highlights the importance of an individual's perceived ability to address that risk in whether or not they adopt an adjustment [12]. Building on this, the PADM and Lindell et al. [33] suggest that individuals consider the efficacy of the adjustment (the degree to which adjustment activities reduce risks), costs associated with the adjustment (in both time and financial investment required), and perceived implementation barriers (such as requirements for cooperation or specialized knowledge) when determining whether or not to adopt a mitigation measure. These variables are used in several earthquake preparedness study to understand survey respondents' attitudes towards different hazard adjustment activities [2,3,33,38].

Previous work in this area supports many of the relationships proposed by the theories and models discussed above. For example, previous studies found that the perceived effectiveness of mitigation actions has a strong influence on both adoption intention and actual