'DROP, COVER AND HOLD ON' OR 'TRIANGLE OF LIFE' ATTRIBUTES OF INFORMATION SOURCES INFLUENCING EARTHQUAKE PROTECTIVE ACTIONS

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ABSTRACT

A well-known fact is that an earthquake or earth shaking does not cause injuries and deaths. Rather, buildings and infrastructure systems collapsing on people do. Hence, reputable government organizations from countries prone to high earthquake risks are heavily invested in advising their populations on immediate lifesaving protective actions (PAs). One such action is the 'Drop, Cover and Hold on' strategy proven to have saved countless lives. Unfortunately, in recent years another action known as the 'Triangle of Life' has been trolled through internet sites and hearsay. It is believed that adopting such an unsubstantiated erroneous action is likely to put people at greater risk during an earthquake. Thus, there is a need to extend studies to understand factors that influence people's decisions to take certain PAs over another for earthquakes. This research does that through an empirical study of 647 residents from Mianyang City in the Sichuan province of China. The results indicate that if a PA is easy to understand, mentioned often by multiple sources and easy to access, then people will adopt it. But a striking finding is that people are also likely to be influenced by wrong information, depending on who is providing such information and through which medium (e.g. social media). These findings suggest that the Chinese government needs to provide gate keepers who are dedicated, trained personnel who can monitor misinformation on various Internet sites and address them. In parallel they can provide regular, up to date public advisories on immediate PA through multiple legitimate government, private and non-profit sector sources and channels.

Keywords: drop, cover and hold on, earthquake protective actions, information sources, risk communication, triangle of life.

1 INTRODUCTION

A press release by the United Nations International Strategy for Disaster Reduction (UNISDR) on 24th January 2019, summarized weather-related impacts in 2018 globally and noted that 'earthquakes and tsunamis accounted for the majority of the 10,373 lives lost in disasters last year, while extreme weather events accounted for most of 61.7 million people affected by natural hazards, according to analysis of 281 events recorded by the Centre for Research on the Epidemiology of Disasters (CRED) in its EM-DAT (International Disaster Database)' [1]. Numerous studies across the world have summarized that earth shaking is not the cause of deaths from an earthquake but rather structural collapse, falling debris or flying objects that cause causalities and injuries [2]. Hence the immediate actions taken by people when the earth starts shaking are likely to make the difference between whether people survive earthquakes unscathed. Disaster scholars in many developed countries have written extensively on hazard adjustments or protective actions (PAs) that people can take to protect themselves and their families from earthquake risks and factors influencing such decisions [3]. High seismic risk countries like the USA, Japan, Chile, Turkey, India, Indonesia, Guatemala, Papua New Guinea and China, which have responded to earthquakes and searched through the debris of collapsed structures, agree that the 'drop, cover, and hold on' is the most

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appropriate PA to take during an earthquake, as it has helped reduce major injuries and deaths. Alternatives like standing in a doorway, running outside, and the 'triangle of life' posture which calls for building occupants to seek shelter in the void created by standing on the floor next to a solid vertical object instead of sheltering under a piece of furniture are erroneous beliefs based on wrong assumptions and should be ignored [4], [5]. This was also reiterated on the Great Shakeout earthquake drill website last year (2018) in the USA [6], informing interested participants about correct actions to take during the drill on October 18, the international shakeout day.

Despite such government advisories to raise awareness about the safest and most effective immediate PAs, the public at large continue to be influenced by misinformation and erroneous beliefs. In 2004, the Chinese Earthquake Administration communicated an alternative PA with the public. It was suggested that if there was no sturdy furniture to shelter under, a person could stand next to a solid piece of furniture [7]. However, it appears that the public misconstrued this suggestion and started preferring the 'Triangle of Life' posture, which further peaked after the Wenchuan Earthquake in 2008 [8] through the Internet. Subsequent research around the world and in China [9] refuted the efficacy of this action and underscored that it put people at greater risk from falling objects and to be avoided at all cost. Additionally, local authorities like the Emergency Management Office at Guangdong Province [10] also updated their earthquake response promotional materials and underscored that the 'triangle of life' posture was a myth to be rejected. However, there is no research to date in China elucidating if and why people continue to be influenced by such misinformation and adopt dangerous measures for earthquakes protection.

Emergency managers and policy makers can benefit from such an understanding so as to improve risk communication and mitigation. Thus, this research extends other studies conducted in the USA on immediate PAs for earthquake risks [3], [11] to the Chinese context. It specifically analyses the impacts of information source attributes on 647 respondents' intentions to adopt two PAs—(1) the government recommended 'drop, cover and hold on' action and (2) the 'triangle of life' posture deemed unsuitable and dangerous.

The subsequent sections begin with a brief review of literature and description of the theoretical framework to guide the questions. This is followed by an enumeration of the data collection protocol, sample characteristics, and measures used. The findings section discusses results from the correlation and regression analyses used to predict PA selection by demographic characteristics, risk perception, and information source attributes. Finally, the conclusions provide lessons learned and policy implications for the Chinese government.

2 LITERATURE REVIEW

Disaster scholars studying pre-impact PAs or 'hazard adjustments' for earthquake risks in the USA have concluded that when presented with alternatives to protect themselves and their family, people select a certain PA over another if they believe it to be effective in not only reducing the risk but also cost effective in time, effort and money spent. For example, PAs like strapping water heaters and tall furniture is cheaper than purchasing earthquake insurance and may be preferred by many households. Alternatively, learning how to turn off the gas valve to prevent gas leaks and fires at home, although a free action may be difficult for some (e.g. elderly) due to lack of knowledge or ability [3], [11].

Cognitive psychologists studying information processing and perceptions have suggested that people rely on their attitudes and belief systems to evaluate their options before making a selection or decision [12], [13]. These attitudes or beliefs are formed by cognitive processes

[14] which are modelled by the socio-cultural and environmental contexts, personal characteristics [13], [15], and social learning over time [16]. This led to the birth of a popular theory in disaster research called the Protective Action Decision Model (PADM) by Lindell and Perry [13],[15],[17]—illustrating individuals' systematic thinking process of their PA decision making by weighting the impacts of messages, societal stakeholders and social learning processes.

The PADM highlights that although individuals receive information from various information channels and sources, environmental cues and social context, this information is likely to be internalized as personal perceptions, thereby influencing their behavioural responses or decisions to take PAs. This internalization process can be understood by (but not limited to) individuals' perceptions of information sources or stakeholders whose knowledge, expertise, trustworthiness and responsibilities are gauged subconsciously by an individual thereby affecting their behavioural responses [3], [11], [18], [19].

Furthermore, information sources may be characterized or differentiated for their efficacy by their quality-related attributes such as expertise, trustworthiness and perceived responsibility in protecting the individual, or quantity-related attributes such as accessibility [20], [21] and multiplicity of information pieces [21], [22].

The review of literature and the PADM framework helped generate the following research questions for examination:

1. RQ1: Will respondents differ in their evaluation of the different sources of information?
   - Will they be more influenced by quality related or quantity related attributes of the information sources?
   - Will respondents' demographic characteristics be correlated with specific information source attributes?
2. RQ2: Will respondents differ in their preferences of which immediate PAs they take?
   - Specifically, would they be more likely to adopt the recommended action (i.e. drop, cover and hold on posture), followed by other actions like immediately evacuating and not the erroneous action (the 'triangle of life' posture)?
3. RQ3: How will respondents' PA decisions be affected by their perceptions of information source attributes and risk perceptions?

3 METHOD

3.1 Sample population

The data reported here is part of a larger research project led by one of the authors from the Southwest University of Science and Technology (SWUST) China from 13 to 18 January, 2017. The project was pre-approved and funded by the School of Economics and Management at SWUST. A structured survey instrument was used to conduct face-to-face interviews with randomly selected households from two townships, Xin'an and Dayan, in Mianyang City of the Sichuan Province (located along the Longmenshan fault line and struck by the devastating Wenchuan earthquake in 2008).

Of the 705 respondents, 58 respondents completed less than 80% of the survey and had over 15 items missing and thus removed. This yielded an overall sample size of 647 cases generating a high response rate of 91.8%. Of these 52.4% of the respondents were females. On average respondents age was 58 years and they had received 7 years of education, average

household size was four members with an annual household income of RMB$ 21,321 (USD$ 3,243). Respondents' demographic characteristics were generally consistent with the Census data reported in the Sichuan Statistical Yearbook 2017 [23].

3.2 Measures

The survey instrument had three parts. Firstly, respondents were asked to report their demographic characteristics—age, gender, education, annual income and household size. Secondly, following the survey design from previous studies [19], [24], respondents were asked to rate their preferences for information broadcasted by 10 information sources (i.e. local authority, community officer, friends and relatives, other community residents, local TV, national TV, newspaper, radio, the Internet and social media) across five attributes (i.e. accessibility, multiplicity of information pieces, expertise, trustworthiness and protection responsibility), over a 5-point Likert scale ranging from 'Not at all important (= 1)' to a 'Very great extent (= 5).' These measures yielded an acceptable reliability score ($\alpha = 0.73$~0.89) for the five information attributes.

Thirdly, respondents were described a possible scenario where their region was struck by an earthquake of intensity CSIS VIII or stronger as denoted by the Chinese Seismic Intensity Scale level. Unlike the magnitude scales, CSIS is a seismic intensity scale measuring the intensity of ground shaking at a specific area. The CSIS divides the intensity of ground shaking into 12 levels, in which the CSIS level VIII indicates a ground shaking with the peak of acceleration higher than 2.5 m/s^2 which would result in walking difficulties and a moderate risk of destruction. The respondents were then asked to rate what the perceived impacts of such an earthquake would be, with nine choices (i.e. landslide, fire, structural damage in the community, casualties or injuries in the community, personal property damage directly from the earthquake, personal property damage from secondary hazards, casualties or injuries in the household, job disruptions and daily services disruptions), over a 5 point Likert scale as above. These nine ratings on perceived impacts were combined into a new variable called risk perception with an acceptable Cronbach's alpha ($\alpha = 0.80$). Finally, respondents were asked to report which immediate PA they were likely to take, the drop, cover and hold on (recommended action) or the triangle of life (erroneous action) over the same 5 point scale. Variable descriptions and measurement outcomes are summarized in Table 1.

3.3 Analysis

Data analyses include descriptive statistics and mean comparison analyses to understand how respondents rated each of the information sources across the five attributes and which immediate PA they took. Additionally, interrater correlations among 13 variables were computed to better understand the relationships among the variables and demonstrate the effects of each variable on PA adoption. Finally regression analysis models help to understand the mechanisms by which certain demographic characteristics, information source attributes, and risk perceptions influence respondents' intentions to take either one of the PAs or both. Particularly, because the recommended and erroneous PAs were measured using the same scale they were controlled by the same set of predictors in the regression models, such that impacts of each predictor on both PAs could be compared by their effect size directly.

Table 1: Description of variables.

Variables	Descriptions	Mean	S.D.
Gender	Self-reported gender of respondents	0.52	0.5
Age	Self-reported age of respondents	58.16	12.52
Education	Years of formal education	7.11	1.9
Income	Annual household income	21.32k	15.7k
HHZ	Size or number of members in the household	4.23	1.54
Accessibility	Ease of accessing information from the source	2.89	0.8
Multiplicity	Whether multiple pieces of information were provided by the information source	2.82	0.77
Expertise	Level of knowledge and expertise related to earthquake risk and preparedness	3.36	0.67
Trustworthiness	Whether the information source demonstrates trustworthiness towards the population	3.54	0.68
Responsibility	Whether the information source demonstrates responsibility towards the population	3.88	0.74
Risk Perception	Perceptions of what the impacts of an earthquake will be to the population and community	3.73	0.66
Recommended PA	Likelihood to adopt the 'drop, cover and hold on' PA	2.47	1.22
Erroneous PA	Likelihood to adopt the 'triangle of life' PA	2.52	1.24

4 RESULTS

4.1 Information sources and their attributes

Figure 1 shows mean rating scores across all five attributes. Respondents rated higher on quality-related attributes than on quantity-related attributes meaning social and political responsibility of an information source, their perceived trustworthiness and expertise in dealing with earthquake risks were more important to respondents than ease of access and multiple pieces of information from the same source. This was confirmed through a MANOVA indicating that respondents differed in their ratings of information source attributes (Wilks' $\Lambda = 0.03$, $F_{5,\ 642} = 4{,}415.54$, $p < 0.001$). Post-hoc testing also revealed that respondents' considerations on each pair of information source attributes are also statistically different ($t_{646} = 4.36–31.94$, $p < 0.001$).

However, as shown in Table 2, the three quality-related attributes were strongly positively correlated with each other (= 0.75), as was the correlation between the two quantity-related attributes ($r = 0.83$). Whereas, the three quality-related attributes were minimally correlated with the quantity-related attributes ($\bar{r} = 0.39$). This means that information sources that were perceived to be responsible were also trustworthy and had the expertise to handle earthquake risk. However, they were not necessarily easy to access and did not provide multiple pieces of information.

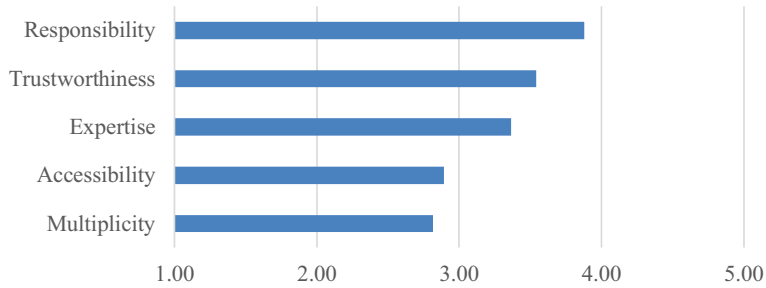

Figure 1: Mean ratings for information source attributes.

As indicated in Table 2, at a 99% of confidence level, younger respondents were more concerned with ease of accessing the information and receiving it multiple times (both $\overline{r} = 0.11$, $p < 0.01$), whereas older respondents were more concerned with the trustworthiness of the source ($r = 0.10$, $p < 0.01$). Findings suggest that larger households and those with higher annual incomes were less concerned with the quality-related attributes. It may well be that they have the family networks and social capital to receive up to date information and help during times of danger, as well as the resources required to respond effectively. Other demographic characteristics only had minor correlations with each information source attribute.

Consistent with previous findings, all three quality-related attributes (expertise, trustworthiness and protection responsibility) were significantly correlated with risk perception (recall it is a measure of perceived impacts if an earthquake struck), whereas there were no significant correlations between quantity-related attributes and risk perception.

4.2 PA preferences

Surprisingly, respondents mean ratings on which PA they intended to adopt were higher for the 'triangle of life' PA ($M = 2.52$), than the government recommended 'drop, cover, and hold on' PA ($M = 2.47$). A follow-up T-test revealed that even though this difference is relatively slight, it is statistically significant ($t_{646} = 2.27$, $p < 0.05$).

Female gender was highlighted correlated with both PAs ($r = 0.12$, $p < 0.01$) which suggests that more women than men intended to adopt the PAs. Household size was also significantly positively correlated with both PAs ($r = 0.10$, $p < 0.01$). Contrary to expectations respondents with more years of formal education were more likely to take the erroneous PA than the recommended one ($r = 0.11$, $p < 0.01$ vs. $r = 0.09$, $p < 0.05$).

Besides, none of the quality-related attributes were significantly correlated with both PAs. However, ease of accessing the information source was significantly correlated with both PAs ($\overline{r} = 0.10$, $p < 0.01$), repeated messaging from the information source (multiplicity) was marginally correlated with both PAs ($\overline{r} = 0.08$, $p < 0.05$), and risk perception was significantly correlated with intended adoption of PAs ($\overline{r} = 0.08$, $p < 0.05$).

4.3 The mechanism of the decision making procedure

To get a nuanced understanding of respondents' decision-making process, different sets of variables were entered into the regression analysis procedure. As indicated in Table 3,

Table 2: The interrater correlation matrix among demographic characteristics, information source attributes, risk perception, and protective actions.

Variables	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**
Gender											
Age	.10**										
Education	.17***	−.31***									
Income	.07*	−.20***	.13***								
HHZ	−.06	−.07	.05	.22***							
Accessibility	.03	−.11**	.07*	.04	.02						
Multiplicity	.02	−.11**	.03	.01	.00	.83***					
Expertise	.00	.06	.07*	−.10**	−.12**	.40***	.41***				
Trustworthiness	.05	.10**	.05	−.10**	−.14***	.40***	.41***	.84***			
Responsibility	.02	−.03	.07*	−.05	−.15***	.35***	.37***	.69***	.73***		
Risk Perception	−.07*	−.06	.00	−.06	−.03	−.03	.00	.11**	.15***	.16***	
Recommended PA	.12**	.02	.09*	.06	.10**	.10**	.08*	.01	−.02	−.06	.08*
Erroneous PA	.12**	−.03	.11**	.08*	.10**	.10**	.07*	.02	−.01	−.05	.07*

Table 3: Prediction of intended adoption of PA by demographic characteristics.

	Model I			Model II		
Dependent Variables	**Recommended Action**			**Erroneous Action**		
Predictors	*B*	**Std. Error**	*β*	*B*	**Std. Error**	*β*
Age	0.00	0.00	0.04	0.00	0.00	–0.01
Income	0.00	0.00	0.03	0.00	0.00	0.03
Gender	0.26**	0.10	0.11**	0.28**	0.10	0.11**
Education	0.05	0.03	0.08	0.06*	0.03	0.09*
Household Size	0.07*	0.03	0.09*	0.07*	0.03	0.09*
Constant	1.39	0.37		1.66	0.38	
F		4.09***			4.60***	
df		5			5	
Adj R^2		0.03			0.03	

* $p < .05$; ** $p < .01$; *** $p < .001$.

Models I and II only controlled demographic variables to identify which demographic characteristics of the respondents may be responsible in influencing the intention to take the wrong PA. The results indicate that gender is the best predictor for both models ($\beta = 0.11$, $p < 0.01$, respectively) and household size also receives a marginal effect on both PAs ($\beta = 0.09$, $p < 0.05$, respectively). Particularly, education has a marginal effect on the erroneous action ($\beta = 0.09$, $p < 0.05$), but not the recommended action.

In Models III and VI (see Table 4), information source attributes, risk perception and demographic characteristics were all entered together to gauge their effect onto PAs. Findings suggest that upon controlling all the variables together, the effect sizes of each predictor varied from the correlation analysis reported above. Particularly, risk perception, which only received a marginal correlation for both PAs, became the primary predictor with most significant effect in both models ($\beta = 0.11, 0.12$, $p < 0.01$, respectively). Similarly, responsibility, which originally had nonsignificant correlation with both PAs, had a marginally negative effect on the adoption of both PAs ($\beta = -.15, -.13$, $p < .05$, respectively). It is noteworthy that accessibility, which originally had strong correlations with both PAs, is the most significant predictor of the erroneous action ($\beta = .14$, $p < .05$), but not of the recommended action.

5 DISCUSSIONS AND CONCLUSIONS

The findings regarding the effects of demographic characteristics on information source perceptions and PAs is in line with previous risk communication studies [11], [25]. Furthermore, the finding that females were more likely to select both PAs is in line with other scholars' findings [26], [27]. However, the nonsignificant correlation between gender and information source perceptions is different from other studies and needs further research. In others clarifying whether Chinese men and women perceive the credibility of information sources differently or equally depending on the nature of the hazard and the cultural context will add to disaster literature in an Asian context.

Table 4: Prediction of intended adoption of PA with all variables.

	Model III			Model IV		
Dependent Variable	**Recommended Action**			**Erroneous Action**		
Predictors	*B*	**Std. Error**	*β*	*B*	**Std. Error**	*β*
Age	.01	.00	.06	.00	.00	.00
Income	.00	.00	.04	.00	.00	.04
Gender	.27**	.10	.11**	.29**	.10	.12**
Education	.05	.03	.08	.06*	.03	.09*
Household Size	.06	.03	.08	.06	.03	.08
Accessibility	.20	.11	.13	.21*	.14	.14*
Multiplicity	.02	.11	.01	-.03	.11	−.02
Expertise	.19	.13	.10	.26	.14	.14
Trustworthiness	−.13	.14	−.07	−.19	.14	−.10
Responsibility	−.24*	.10	−.15*	−.21*	.10	−.13*
Risk Perception	.23**	.07	.12**	.20**	.07	.11**
Constant	.59	.54		.93	.54	
F		4.15***			3.98***	
df		11			11	
Adj R^2		.07			.05	

* $p < .05$; ** $p < .01$; *** $p < .001$

It is interesting to note that a larger size household with better economic status is less likely to be influenced by quality-related attributes and yet, more likely to adopt both PAs. One possible reason is that such individuals would have more opportunities and the capacity to communicate with others, shape a groupthink, and in turn have a consensus on choosing a specific PA decision [28]. Consequently, they would be less likely to concern themselves about the quality-related attributes of the information sources.

It is also noteworthy that younger respondents had greater concern with quantity-related attributes than with quality-related attributes i.e. they were more concerned with the accessibility of the information and receiving it from multiple sources rather than softer quality attributes like trustworthiness of the stakeholder providing the information. Even though this finding is likely an outcome of the digital divide or the ICT revolution on information seeking behaviours between the old and young, a few scholars have found that younger respondents are more likely to check the accuracy of the information received, when they have to make a decision [29].

The findings of significant correlations between quality-related attributes and risk perception are important because they imply that authorities can call for public attention to certain threats via credible and credentialed government validated information sources that recommend the public to take adequate PAs [11], [18], [25]. Surprisingly, the results regarding the correlations between information source perceptions and PA adoptions were contrary to previous studies [11], [18], [19] that only quantity-related attributes were correlated with PAs,

but not quality-related attributes. This result implies a 'fast-food style information consumption behaviour'—i.e. a rapid reading or information seeking without thinking—that makes individuals more likely to pay attention to advice easily available on the world wide web for free consumption, and shown repeatedly, without the need to cross check the source. This is not a problem if such information were consistent with the recommended actions [30], but if it is erroneous as is the case with the 'triangle of life' advice, it is detrimental to the success of the risk communication process due to 'availability heuristics' [31], [32].

The findings of the differences on the effects of two quantity-related attributes between recommended and erroneous actions are important because it confirms previous findings that conformist behaviour to adopt erroneous PAs can be challenged and changed if an individual cross checks over multiple sources and examines the authenticity of the information [29], [33], [34]. In addition, individuals' interest in quality-related attributes such as responsibility and trustworthiness would encourage them to better understand the contents of the PA information. This in turn would help them process the information systematically and make an informed decision rather than be purely influenced by availability heuristics [35]. By contrast the significant effect of accessibility on the adoption of the triangle of life action suggests that repeated exposure through multiple media can influence adoption of erroneous actions [36].

In conclusion, the findings suggest that to mitigate the adoption of erroneous PAs and to encourage the public to adopt recommended PAs, the Chinese government should make concerted efforts to educate the public by regularly providing legitimate and validated PA advice through multiple government, private and non-profit sector sources and traditional and new media channels. Also having dedicated, trained personnel to provide minimal monitoring of these sources and provide corrective measures to control rumours will be useful.

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