

FACTORS AFFECTING SURVIVAL IN TSUNAMI EVACUATION

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ABSTRACT

During disasters, every second can be decisive but most people are unable to think clearly, and their decision-making is often illogical and irrational, or at best sub-optimal. In Japan, after the Great East Japan Earthquake (GEJE) and tsunami in 2011, survival was largely determined by timely evacuation. Evacuation procedures are highly developed in Japan and people are drilled in evacuation from childhood.

This paper reports recent research at Kyoto University to document evacuation after the 2011 event and to understand evacuation behaviour and their level of preparedness. One of the aspects studied is the difference between what people say they will do in a disaster and what they actually do in a real event. For example, in Japan many respondents said that they would run to a safe place, but in fact many people went home, often into danger, to seek and care for family members (Murakami and Umezu, 2011).

INTRODUCTION

Many factors have influence on people behaviour in a disaster, either at the time or during recovery process: age and gender, marital status, children, education, social networks, native to area or not, disaster experience, awareness of hazard and preparedness. All these affect the level of risk and the probability of casualty. There is evidence from previous disasters, notably the 2004 Indian Ocean tsunami, that foreign visitors have much greater difficulty than nationals in evacuating in time. There is also evidence that more women die than men, for example in the 1991 Bangladesh cyclone, the 1995 Hanshin-Awaji Earthquake, the 2005 Kashmir Pakistan earthquake and the 2009 L'Aquila earthquake.

In Japan, after Tohoku earthquake in 2011, the majority of deaths were caused by a tsunami that was much larger than had been anticipated and prepared for. There is evidence that the vast majority of nationals evacuated successfully but that many evacuation centres were overwhelmed by the unprecedented size of the

waves. The casualty rates amongst foreigners were as high as predicted by other similar events, but exceptionally, more men died than women. (Koyama et al., 2012)

Timely unambiguous early warning and making the right decision to evacuate immediately are obviously crucial to survival. But what makes people evacuate immediately? And are government programmes of awareness raising and drilling working effectively in Japan? This research produced some surprising results, for example experience of drills had no effect. It was almost as if some people were complacent and thought they had more time. This is perhaps not so surprising.

The Great East Japan Earthquake was the most powerful earthquake known in the history of Japan, also one of the most powerful earthquakes in the world, producing 5% of the global cumulative seismic energy released since 1900 (Witze, 2011). The epicentre was located in the east of Tohoku with a depth of 32 km and the earthquake has affected almost 650 km of the Miyagi, Sanriku, Joban and Kanto coastline along the Pacific Ocean shores of Northern Honshu Island (Witze, 2011). A number of large foreshocks and hundreds of aftershocks are reported for the main earthquake. The main earthquake was followed by a major tsunami with an estimated wave height of 38.9 meters (Yomiuri Shimbun, 2011), and travelled up to 10 km inland in the Sendai area.

JAPANESE EARLY WARNING SYSTEM AND EVACUATION EDUCATION

There has been no lack of effort to research the causes of the high fatality in the 2011 Tohoku tsunami. Mori and Takahashi (2012) report a survey by 300 researchers in more than 5,200 locations. But this research on the action of the tsunami wave rather than the behaviour of people in response.

Commenting on tsunami preparedness researchers at Tohoku University suggest that despite an increased awareness of tsunami risk in many areas of the world, including increased knowledge, disaster preparedness and willingness of local populations to evacuate, the response to tsunami warnings still appears to be inadequate, pointing to lack of awareness by at least some individuals, an over-reliance in defence mechanisms or a failure to transmit knowledge from previous events. (Esteban et al., 2004).

A survey of published research by Christopher (1979) determined that individual and group reactions to natural disasters differ greatly and depend partly on personality. The author described four models that explain individual and group reactions to natural disasters.

The possibility of warning is conditioned by the extent to which the different types of disaster can be predicted reliably (Fritz and Williams, 1957). Japanese earthquake engineers are amongst the best in the world and scientific considerable effort has been directed to earthquake prediction (Davis, 2012). A prediction for the GEJE 2011 was initially announced in mid 2001 nearly ten years in advance of the earthquake identifying the possibility of a magnitude M8.0 or greater earthquake occurring in an area covering northern Honshu and Hokkaido. What the scientists failed to anticipate were both the size of the 2011 event (M9.0) and the detailed response of the affected population. Both these factors contributed to the high death toll. This paper examines some important aspects of behaviour to affect survival rates.

The accepted wisdom, at least prior to 2011, was that Japan was as prepared for earthquakes as any nation and that its people, through extensive training, drill and education programmes were ready to respond appropriately to protect their lives. A well-developed public earthquake early warning (EEW) system has been operating in Japan since October 2007. People near the epicentre received the EEW about 15 to 20 seconds before the most severe shaking occurred. Even such a brief warning contributes significantly to saving lives (Murakoshi et al., 2008).

Some 90% were able to take advance actions to save their own lives and those of family members. Fujinawa and Noda (2013) argue that this high rate of effectiveness is the result of education both in schools and in society at large. People in Japan had been imagining an earthquake and training themselves regarding what actions should be taken when an EEW is issued, and this advice is given at schools, by the local government and mass media. Comprehensive earthquake safety manuals were written by Prof. K. Meguro of Tokyo University (Meguro 2012) to make people familiar with earthquake risks and to prepare to take the most suitable action depending on 'time, position, and occasion'. The development of systems for schools was led in particular by Professor M. Motosaka of Tohoku University (Motosaka and Homma, 2009).

But this view of readiness has been challenged, not least by the huge death toll caused by the tsunami. Comfort (2011) suggests one reason for the apparent lack of preparedness for the tsunami was that the



Disaster Countermeasures Basic Act of 1961 that assumes a common level of response to all types of hazards. Although Japan has experienced tsunamis, they were not identified as a disaster category that merits attention on its own. Instead, countermeasures for tsunamis were treated as a need generated by earthquakes. To what extent this played a role is uncertain. What is clear is that the size of the tsunami was much greater than people had anticipated and many people were unable to evacuate in time.

Yun and Hamada in a forthcoming paper highlighted the difference between 66% of the survivors who evacuated within 20 minutes and only 11% of the survivors who did not or could not evacuate. The reasons people gave for not evacuating in time were: a belief that their current location was safe enough; waiting for additional information. Additionally, 30% of people who evacuated within 20 minutes and became victims had difficulty reaching an evacuation centre, or going to an unsafe refuge. 20% of people who didn't evacuate in time but who survived went back to their houses or other places before the tsunami ended to find family members, and returning to their homes to find their belongings. This finding supports previous research by Suppasri et al. (2012); Quarantelli (1985) and Riad (1999). The authors conclude that that early evacuation and safe location are key factors that lead to survival.

The Japanese Government and scientific community have learnt the lessons from the 2011 tsunami, not least in terms of communication. Before a disaster the media, including the press, radio and television as well as social media, can be most influential in increasing people's preparedness and awareness of the risk. And after a disaster, the media has an important role in informing people about the level of risk and evacuation to the safe areas (Amini Hosseini et al., 2011). In particular the exact form of the early warning has been simplified to ensure that people evacuate immediately without stopping to calculate, based on the predicted magnitude, whether they have time to delay or do something else, such as rescue friends, family or belongings.

Gantt (2012) in a review of disaster psychology literature entitled 'Dispelling the myths of panic' conclude that human responses during disasters are rarely consistent with those expected by the government and the media. Unfortunately, these perceptions have crept into disaster management folklore. A careful review of social science and disaster research suggest that rather than responding in irrational and/or self-interested ways, people typically respond in rational and pro-social ways.

Perry and Greene (1982), suggest that three factors directly affect an individual's ability to properly assess the risks from a disaster or emergency. These include credibility of the authority; the warning message itself, including any risk relevant information; and past experience with similar scenarios.

One way of attempting to understand what at first sight appears to be irrational behaviour by people not evacuating immediately is in terms of risk taking. Cameron and Shah (2013) investigated the relationship between natural disasters and individuals' risk-taking Behaviour using data from experiments conducted in Indonesia in 2008. They found that individuals living in villages that have experienced a natural disaster behave in a more risk averse manner than individuals in otherwise like villages. Their data suggest that expectations change as a result of having experienced a natural disaster. People who have recently experienced a disaster attach a higher probability to experiencing another in the next twelve months and expect the impact to be more severe than people who have not experienced one. This may go some way to explaining why survivors are so risk averse now and place such a premium on safety. But their work does not address the more interesting question of why so many people took a risk in not evacuating immediately in the Tohoku tsunami.

EVACUATION BEHAVIOUR

Considering the gap between the main earthquake and arrival of tsunami waves, and the fact that it happened during daytime, it was expected that people in the affected areas should have been at relatively high disaster preparedness levels. But in the first 10 minutes nobody tried to evacuate, then a few people, who were living in the nearest areas to coast line left their homes to escape from danger, while most residents, especially those in areas far from the sea, started to run to a safe zone about half an hour after the main shock (Murakami et. al. 2012). In farther area, people did not take the warning of 2011 tsunami seriously by remembering their last tsunami experience in the same place and assumed that the tsunami would have a low inundation height. Accordingly, in 2011, many people delayed the evacuation and did not attempt to escape in time. However, the 2011 tsunami was much more severe than any previous tsunami in living memory and one and produced a much higher inundation compared to 2010 Chilean tsunami. It seems



that people's background image from recent events clouds their judgment and affects their reaction when encountering a new event. It seems that being closer to the danger zone is a crucial factor in people's preparedness.

In addition there are other factors that play a vital role in critical moments. Multiple announcements on the radio about tsunami height, particularly is the Natori city which was first declared 6 meters and then over 10 meters Murakami and Umezu (2011), spread doubt made people discredit the warning and cause critical loss of time. The second announcement, which indicated a higher inundation height, provoked people to relocate to a place of higher altitude. Some of them were hit by the tsunami and washed away because they lost time by obeying traffic rules and sticking in slow moving or congested traffic.

We interviewed thirteen survivors who were living in temporary housing. Four women and nine men, ten were over 45 and three were less than 45 years old. As Table 2 shows only one out of the thirteen people ran away in time. He was a 13 year-old boy. All other twelve just attempted to help others or tried to return home for any reason other than escape. Five of the survivors were actually hit by tsunami and could only survive with great difficulty. One of them was in water for 24 hours. Of the five who went to help others, they all mentioned trying to convince elder people to leave their houses and helping them which made their evacuation speed much slower.

Table 1. Reaction after the tsunami warning

Total	Use car to evacuate	Help people	Return Back home	Run to safe place	Trapped by tsunami
13	6	5	7	1	5

Factor influencing fatality rates:

1. Making right decision in time to run to safe and avoid wasting time in the critical situation rather than going back home.
2. People's preparedness and awareness, being familiar with this kind of intensity of disaster in the area they lived.
3. Having accurate and realistic assessment of the risk rather than an over optimistic impression created by a smaller recent disaster such as the Chilean Tsunami.
4. Cultural inhibitors on people's behaviour, for example obeying traffic regulations and road signs in a crisis situation when the normal rules of behaviour might usefully be suspended.
5. Multiple announcement on the radio about tsunami height caused doubt, disbelief and loss of time.
6. Helping people and seeking family members.
7. Distance to risk centre. Fatalities were higher amongst those furthest from an evacuation centre.
8. Time lost convince elder people to evacuate and helping them move.

ATTITUDES TO RISK

The previous sections examined how people behaved after the main shock of 2011 Tohoku earthquake early warnings and the critical issues that influenced people's decision making. This section examines the people's attitudes to risk and how they imagine they will behave in the abstract while no danger threatens them and they have to imagine themselves in the crisis. It is based on a questionnaire amongst students at Kyoto University and other universities in Japan all of whom were aware of and sensitive to the 2011 disaster. The aim of this survey was to investigate in greater depth why people seem to have problems making the right decision to evacuate immediately to a safe area and what factors might influence people's behavior. Greater understanding of the thinking processes of people when they imagine themselves in a similar crisis will help devise policies to reduce fatalities in future disasters. It would be possible by comparing the result of questionnaire with what we could find through our interviews and site surveys.

The questionnaire was distributed amongst graduate and undergraduate students including different nationality and gender on paper after various university lectures and disseminated on the Internet. There a total of 215 responses, 121 from the paper based version and 94 on the Internet. Of these 186 respondents answered the relevant questions about response, nationality etc.

The respondents came from 41 different countries. For the purpose of the analysis presented here they are divided into Japanese (19%) who are familiar with their country and had been drilled in tsunami



awareness and evacuation procedures since childhood, and foreigners (81%) who in the main were not trained in tsunami evacuation but most of them have experienced the 2011 tsunami either directly or indirectly. The respondents' level of tsunami awareness was tested with a number of questions about awareness, preparedness, experience, and knowledge of his or her living area and understanding of the types of natural disaster that might threaten them. The main question was: "If earthquake occurs then what would be your reaction?" The pre-coded possible answers were: "Run to the safe area, return home, help other people or looking family member? This pre-coded range of possible behaviour was derived from findings from previous research described earlier about people's actual reactions in the 2011 tsunami.

Table 2 presents the breakdown of respondents by gender, nationality and marital status. 56% were men and 44% women; 24% were married and 76% single; 19% were Japanese nationals and 81% were foreigners.

Table 2. Reaction after the tsunami warning

Nationality	Men	Women	Married	Single	Total
Japanese	22	13	1	34	35
Foreigner	82	68	43	106	151
Total	104	81	44	140	186

The analysis the data had thrown up some interesting and unexpected results presented in the three following summary tables. (The statistical significance of the findings is measured using Chi-Square, where the ratio reported is the probability of the samples being the same i.e. 1 is 100% probability that there is no difference.

ANALYSIS OF PEOPLE'S BEHAVIOUR

Table 3 shows the difference in the behaviour of men and women among participants, more men than women said they would help other people rather than run to safe area (Chi-Square 0.17), and more significant difference is shown for single people who help people in crisis than married people (Chi-Square 0.02), but what is most noteworthy is that having or not having experience of tsunami drill appears not to affect behaviour, and particularly whether people help others.

Table 3. Effect of Gender, Marital status, Having drill experience on helping people in emergency situation

	Women	Men	Married	Single	Having drill experience	No drill
Helping people	16%	24%	7%	22%	22%	17%
Other	84%	76%	93%	78%	78%	83%
Number responses	184		197		201	
Chi-Square	0.17		0.02		0.45	

In Table 4 the authors analysed the importance of being native to area, Surprisingly a higher proportion of foreigner help others than do Japanese, The behaviour of Japanese may be due to their greater understanding of the danger.

Table 4. Nationality and reaction

	Foreigner	Japanese		Foreigner	Japanese
Helping people	24%	6%	Looking for family	37%	38%
Other	76%	94%	Other	63%	62%
Number responses	173		Number responses	173	
Chi-Square	0.02		Chi-Square	0.93	

Car ownership affects whether people, particularly those work over 20 minutes from home, go to rescue a family member. (Chi-Square 0.02, Table 5), Four times as many people with private car go in search of family than those dependent on public transport. Clearly they know that the public transport will stop running and they have no chance of reaching home in the time. Car ownership does not affect whether people go to help others. Clearly there will be people living nearby – friends, neighbours or strangers – who are in need of immediate help and people disposed to help others are not dependent on transport to provide assistance.

Table 5. Effect of transportation mode on people behaviour between looking for family and helping other people

	Private vehicle	Public transportation		Private vehicle	Public transportation
Helping people	16%	24%	Looking for family	24%	6%
Other	84%	76%	Other	76%	94%
Number responses	92		Number responses	92	
Chi-Square	0.96		Chi-Square	0.02	

Table 6. Effect of having disaster experience for people reaction between looking for family and helping other people

	Experience of disaster	No Experience		Experience of disaster	No Experience
Helping people	22%	15%	Looking for family	34%	38%
Other	78%	85%	Other	66%	63%
Number responses	181		Number responses	181	
Chi-Square	0.18		Chi-Square	0.64	

Table 7. Volunteer experience and being friendly's effect of helping other people in emergency time

	Volunteer experience	No volunteer	Easy to make friendship	Not friendly
Helping people	20%	19%	22%	12%
Other	80%	81%	87%	88%
Number responses	204		120	
Chi-Square	0.87		0.17	

Table 8 shows distance to home has no effect on people helping others.



Table 8. Effect of distance on helping people in emergency time

	>20 minutes distance	20 minutes distance
Helping people	21%	20%
Other	79%	80%
Number responses	179	
Chi-Square	0.90	

METHODOLOGY

Two methodological issues need to be highlighted. Firstly, it should be emphasised that this research is based on a sample of only 200 people living in Japan after the tsunami who were imagining how they would respond rather than actual behaviour of survivors. Clearly people rarely act exactly how they imagine. And it would be difficult for people in other places to imagine what would happen in a tsunami. However, the majority had recent experience of the 2011 tsunami. They were living in Japan and had either direct experience of surviving the tsunami or had friends or relatives who had. Secondly the respondents were mainly students and therefore unrepresentative of the wider population in terms of age profile and educational level in particular.

CONCLUSIONS

This paper reported research designed to isolate the factors that determine whether people, faced by the warning of an imminent tsunami, would help others rather than fleeing to a safe place. The findings can be divided into four categories.

Firstly, the factors having the biggest positive impact are close-to-reality evaluation of risk, a concise and specific warning given to people at the right time, and lastly people's capability for coming up with the right choice of action. Secondly are factors such as sex, marital status, whether people are native to the area, and the extent to which people have made proper preparations which might have a significant effect in saving lives.

Thirdly are factors that most surprisingly seem to have little impact in evacuation choices and survival rates, saving people's lives include, namely, prior training, awareness raising and drilling. Private vehicle ownership, has an effect on whether people decide to go in search of family members, but has little effect on whether they help others.

Fourthly, there are those factors that seem to have a negative effect, most notably previous experience of natural disasters. In contrast to other studies that found people were more risk averse after having experienced a previous disaster, this study found that those with experience of disaster were more likely to go to help others rather than evacuate to a safety zone.

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