

# Study on Residents' Disaster Prevention Awareness for Tsunami in Valparaíso, Chile

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## Abstract

We conducted two questionnaire surveys to investigate the tsunami disaster prevention awareness for the residents in Valparaíso, Chile. One was conducted on April 2015 and the other was conducted December 2015. The second one was conducted after the Illapel Earthquake and Tsunami occurred on September 2015.

The number of the questions is 30 and 23 for the first survey and the second survey, respectively. In this paper, the results of the typical questions are shown as follows; (1) They have the correct knowledge or not. (2) They have had the education about Tsunami and Tsunami evacuation. (3) They make a Tsunami risk communication with their family. (4) They know the Tsunami hazard/risk map in Valparaíso. These results are compared between the first survey and the second survey. These results indicate that proportion of the answerers who choose the positive answer is not so much high, and there is no significant difference between the first survey and the second survey.

The evacuation behavior to the Illapel Earthquake was also investigated and some results are shown in this paper. Moreover, we conducted the covariance structure analysis with data of the second survey to tried to reveal what factor make the residents start evacuating.

Keywords: Valparaíso, Tsunami Disaster Prevention Awareness, Questionnaire Survey, the Illapel Earthquake in 2015

## 1. Introduction

In recent years, large-scale earthquakes have occurred frequently all around the world. These earthquakes can induce tsunamis and cause massive damage. Since the cost in human casualties of tsunamis tends to be high, we need to consider appropriate disaster prevention and evacuation measures. Evacuation measures are among the effective ways to reduce the human casualties. However, evacuation measures quite depend on disaster prevention awareness of residents. As known widely in the world, the tragic Chile Earthquake and Tsunami in Talcahuano of 2010 resulted in loss of lives among many residents and huge damage of around 80% of houses in this city. Immediate action for Disaster Risk Reduction as a countermeasure against next disaster is needed in whole of Chile. Hence, we have attempted to investigate residents' Tsunami disaster prevention awareness in Valparaíso as a target area for earthquakes and tsunamis.

Valparaíso is located 111.8km northwest of Santiago and one of the most important seaports facing the south Pacific. Valparaíso is the capital of Chile's third populated administrative region and was declared the world heritage site in 2003. Valparaíso and Viña del Mar (a city next to Valparaíso) are very famous resort cities, favorite tourists' destinations for locals and foreigners. Valparaíso City has less experience of massive tsunami disasters in recent year. However, major earthquakes and tsunamis are expected in the near future.

A questionnaire survey was conducted to investigate the tsunami disaster prevention awareness for the residents of target areas in April 2015. After five months from this questionnaire survey, the Illapel earthquake and tsunami occurred. The Modified Mercalli Intensity IX was recorded in Valparaíso and Tsunami also attacked the shoreline of Valparaíso. Therefore, in December 2015, we also conducted the second questionnaire survey to investigate the evacuation behavior. Based on the two questionnaire surveys, we investigated the



tsunami disaster prevention awareness and the evacuation behavior of the Illapel Earthquake and Tsunami. This paper presents the results of these questionnaire surveys.

There are a lot of studies in Japan regarding residents' disaster prevention awareness about mega earthquake and tsunami. The Asian Disaster Reduction Center (ADRC)<sup>[1]</sup> conducted a questionnaire survey in Banda Aceh, which was severely impacted by the Indian Ocean Tsunami of 2004. In that survey, 88.5% of residents indicated that they "didn't know anything about tsunamis before the disaster in 2004." It was found that there was lack of knowledge regarding basic disaster knowledge in Indonesia. As regards Chile, Dr. Imamura did a study about Chile earthquake of 2010<sup>[2]</sup> and Dr. Kanai conducted a questionnaire survey <sup>[3]</sup> regarding residents' disaster prevention awareness among people in Japan who were reached by the Chile earthquake. This survey found that one of the reasons why people failed to evacuate was due to uncertain alarm information provided. Cabinet office in Japan conducted questionnaire survey in Tohoku region where it was affected by the Tohoku Earthquake and Tsunami in 2011.<sup>[3]</sup> In this report, it was pointed out that one of big factor of evacuation is leading evacuation and calling from neighbors. As these studies, there are different disaster prevention awareness about tsunami in each region and country.

# 2. Outline of Questionnaire Survey

The location of Valparaíso is shown in Fig. 1. The first questionnaire survey was conducted in early April 2015 and the second on 1st December 2015. Both surveys were conducted by the students of University of Valparaíso who were supervised by the third author of this paper. The students, serving as investigators, went out to the downtown with the questionnaire forms and asked the respondents to fill in the form and collected it. The number of the respondents was 77 for the first survey and 99 for the second survey. Table 1 shows the gender and age-group of respondents. Fig. 2 shows the occupation of the answerers.

	Number	Gender		Generations										
		Male	Female		10's	20's	30's	40's	50's	60's	over 70's	unknown		
The 1st	77	37 (48.1 %)	40 (51.9 %)		13 (16.9 %)	30 (39.0 %)	8 (10.4 %)	5 (6.5 %)	10 (13.0 %)	7 (9.1 %)	4 (5.2 %)	0 (0 %)		
The 2nd	99	45 (45.5 %)	54 (54.5 %)		13 (13.1 %)	36 (36.4 %)	21 (21.2 %)	11 (11.1 %)	8 (8.1 %)	6 (6.1 %)	3 (3.0 %)	1 (1.0 %)		

Table 1 Gender and Age-group of Respondents



Fig. 1 Location of Valparaíso



Fig. 2 Occupation of Respondents



The first questionnaire consists of 30 questions and the second questionnaire consists of 23 questions. The questions are summarized in Table 2. The circle mark means that the questions described in the questionnaire form. The equations can be classified into some categories, i.e. knowledge, interest, activity, crisis, responsibility, effectiveness.

Category	Question	The 1st	The 2nd	Score
Personal	Gender	0	0	
Information	Generation	0	0	
Information	Occupation	0	0	
	Do you think Tsunami is always small if the shaking of the earthquake is small?	0	0	"Vos storpgly"-1 "Vos"-2
Knowledge	Do you think it is still safe to start evacuating once you can see Tsunami coming?	0	0	- "No"=3, "No,at all"=4
	Do you think that tsunami always starts with an ebb tide?	0	0	
	Do you know following past tsunami?	0	0	
Education	Have you ever heard stories or tales about tsunamis or evacuation from your family members?	0	0	"Yes,storngly"=4, "Yes"=3,
Education	Have you ever had a lesson regarding tsunami disaster prevention at your school?	0	0	"No"=2, "No,at all"=1
Communication	Do you talk with your family members about tsunamis or tsunami evacuation?	0	0	The same as the Education
Internet	Are you interested in Tsunami?	0	-	
Interest	Are you interested in disaster prevention against tsunami or evacuation for tsunami?	0	-	
Responsibility	Do you think you have a responsibility for protecting yourself and your family from Tsunami and/or Earthquake	0	0	The same as the Education
E#astingases	Do you think orientation regarding tsunami disaster prevention is effective for disaster risk reduction?	0	-	
Effectiveness	Do you think evacuation drill is effective for disaster risk reduction?	0	-	
Traublasama	Do you think it is burden to join for orientation regarding tsunami disaster prevention?	0	-	
noublesome	Do you think it is burden to join for evacuation drill?	0	-	
Affection	Do you love your town?	0	-	
Crisis	Do you think Chile will have massive tsunami in the near future?	0	-	
Clisis	Do you think risk awareness and sense of fear for disasters?	0	-	
	Is there any orientation regarding tsunami disaster prevention at work place or local community?	0	0	
	Is there any evacuation drill at work place, school or local community?	0	0	
Liezard/Diel: Men	Do you know about tsunami hazard maps in your town?	0	0	The same as the Education
	Do you think tsunami hazard maps is effective for disaster risk reduction?	0	0	The same as the Education
	Where were you when earthquake occurred?	-	0	
	Did you stand during earthquake?	-	0	
	Did you feel a fear of sense during earthquake?	-	0	
	Did you hear alert or siren?	-	0	
Illapel Earthquake	Did you evacuate?	-	0	
	(for evacuated parson) What is the biggest reason why you evacuated?	-	0	
	(for evacuated parson) When did you start to evacuate after earthquake?	-	0	
	(for evacuated parson) What is method of evacuation?	-	0	
	(for non evacuated parson) What is the biggest reason why you did not evacuate?	—	0	

### Table 2 List of Question

## 3. Results and Discussions

#### 3.1 Results of typical questions

There is enough space to describe the results of the all questions, so only the important results of these surveys are discussed. Fig.3 shows the results of the question, "Do you think Tsunami is always small if the shaking of the earthquake is small?", and Fig.4 shows the results of the question, "Do you think it is still safe to start evacuating once you can see Tsunami coming?"







Fig.4 Results of Question: Do you think it is still safe to start evacuating once you can see Tsunami coming?



The basic knowledge about the characteristics of Tsunami was asked with these questions. Tsunami can be large even if the shaking of the earthquake is small, so the answer we expect is "No" or "No at all". Similarly, in fig 4 the answer we expect is also "No" or "No at all" because the speed of Tsunami is fast enough that there is no sufficient time to evacuate.

We found that 40% of respondents for the first survey and 56% for the second survey have the insufficient knowledge as shown in fig.3. In particular, 30% residents and 20% of respondents have insufficient knowledge as shown in fig.4.

Fig. 5 shows the results of the question, "Have you ever heard stories or tales about Tsunami or evacuation from your family?" About 48% of the respondents of the first survey and 70% of the respondents of the second survey reported to have heard the stories or tales from their family. Fig.6 shows the results of the question, "Do you talk with your family about Tsunami disaster or Tsunami evacuation?" About 40% of the respondents of the first survey and 45% of the respondents of the second survey reported to have discussed Tsunami risk with their family. However, we could also say that almost 50% of the respondents did not have those discussions. There is no significant discrepancy between both results that even after the Illapel earthquake still half of the respondents didn't make the Tsunami risk discussion.





Fig.5 Results of Question: Have you ever heard stories or tales about Tsunami or evacuation from your family?

Fig.6 Results of Question: Do you talk with your family about Tsunami disaster or Tsunami evacuation?

Fig.7 shows results of the question, "Do you know Tsunami hazard/risk map in your city?" About 42% of the respondents in the first survey and 32% of the respondents in the second surveys know about the Tsunami hazard/risk map. The Tsunami hazard/risk map might be not known widely in Valparaíso. Fig.8 shows the results of the question, "Do you think Chile will have massive Tsunami in near future?" This question is asked to only the first survey. Cities or places are not pointed out in this question, just asking Tsunami will attack anywhere in Chile. In this question, about 75% of the respondents believe that it will attack Chile in the near future.



Fig.7 Results of Question: Do you know Tsunami hazard/risk map in your city?



Fig.8 Results of Question: Do you think Chile will have massive Tsunami in near future?



As shown in Table 2, the questions form some categories. We evaluated these categories quantitatively, and calculated the averaged score according to the score shown in table 2. These averaged score can be obtained for each question. The category of "Knowledge" consists of three questions. In this case, this category is estimated by averaging three averaged score. This evaluation is called "Averaged Score".



Fig.9 Averaged Score of each Categories

Fig.9 shows the Averaged score for all categories. This figure also shows the comparison between the first survey and the second survey. If all respondents provided positive answer, which is "yes, strongly", the averaged Score would take 4 and take 1 vice versa. All the averged scores are ranging from 2.0 to 2.6. The score 2.5 could be nutral, so that the estimations for all categories are neutral or a little bit negative. There is a 5% significant difference between them in the category "Tradition". Except that there is no difference statistically. The respondents of the second survey were, of course, different from the second survey.

### 3.2 Tsunami evacuation behavior in the Illapel earthquake

In this section, we will discuss the Tsunami evacuation behavior when the Illapel earthquake occurred. Fig.10 shows the results of the question, "Where were you when the earthquake occurred?" The answer "Home" accounts for 63%. The Illapel earthquake occurred at 8:00 pm. This was a time for many residents to be in their home. Therefore, this is why that answer "Home" shows as the maximum. Fig.11 shows the results of the question "Were you able to stand during the earthquake?" Although the intensity of the earthquake in Valparaíso was IX, almost all of the respondents were able to stand.

Fig.12 shows the results of the question, "Did you hear the Tsunami alert or siren?", and Fig.13 shows the results of the question, "Where did you evacuate from the Tsunami?" The Tsunami alert was officially announced 5 minutes after the earthquake occurred. We can understand that almost all residents heard the alert, but 62% of the respondents didn't evacuate. One of the reasons is that they were in their home and the houses and the apartments were built on hills. Almost all respondents did not to evacuate because they were already in the safe place.



Home Working Place School Bus, Car etc Others Fig.10 Results of Question: Where was you when the earthquake occurred?



Fig.11 Results of Question: Was you able to stand during the earthquake?



Fig.12 Results of Question: Did you hear the Tsunami alert or siren?





Fig.13 Results of Question: Where did you evacuate from the Tsunami?

#### 3.3 Covariance Structure Analysis

A causal relationship was confirmed between "Whether or not you evacuate" and representative questions using the Covariance Structure Analysis. Fig. 14 shows the model and the analytical results. This analysis was conducted using data of the second survey. For an accurate Covariance Structure Analysis to be conducted, the GFI should be more than 0.9. The result in Fig. 14 slightly falls down this level. However, this figure is still utilized in the results of this paper since the value does not fall down the standard.

There are three items that is real situation as "Did you feel a fear of Earthquake", "Did you hear alarm or siren?" and "Did you stand during Earthquake?". There is a middle coefficient of 0.34 between "Whether or not you evacuate" and the question on "Did you feel a fear of Earthquake". It is predicted that this is due to effective information which was provided by the government. Also there is a middle coefficient of 0.30 between "Whether or not you evacuate" and "Family, Community" which consists of the question "Storytelling about tsunami" and "Conversation with your family member". On the other hand, there is a minus coefficient of -0.30 between "Whether or not you evacuate" and "Disaster Education" which consists of 3 questions. Not that the definition of "Education" is not the same as that of Fig.9. It is predicted that "Disaster Education" is not triggered for evacuation but it is most important to learn the correct knowledge such as appropriate behavior in evacuation site, mutual support with residents, etc.



Fig.14 Model of Relationship between Evacuation and Related factors



# 4. Concluding Remarks

In this study, The questionnaire surveys regarding the Tsunami disaster prevention awareness were conducted for the residents in Valparaíso. The main results are summaried as shown below.

- 1) The correct disaster knowledge is not enough. Strengthened capacity building for resident is needed via disaster education at school or community.
- 2) The risk communication with family is not enough. Especially, around 55-60 % answerers do not talk about tsunami disaster and evacuation with family. More positive conversation is important.
- 3) The average score between the two surveys has almost no difference,. The Illapel earthquake did not affect residents' disaster prevention awareness in Valparaíso.
- 4) 70.4 % answerers heard the tsunami alert or siren but 64.2 % resident did not evacuate. An effective method which provides disaster information for residents such as tsunami alert or siren should be considered.
- 5) 62% answerers didn't evacuate from the Tsunami because they were in their house and the houses or the apartments are built on hills.
- 6) The covariance structure analysis was made to reveal the factors which make the residents start to the evacuation behavior. It is found that the alarm or Family is the important key to evacuate.

# 5. Acknowledgements

This study was supported by the Science and Technology Research Partnership for Sustainable Development (SATREPS) entitled "Research Project on Enhancement of Technology to Develop Tsunami-resilient Community". We would like to express our deepest gratitude to Professor Takashi TOMITA, Professor Fusanori MIURA, Ms. Toshimi KOBAYASHI, Ms. Tazuko ICHINOHE and Ms. Hiroko SUZUKI for their kind supports.

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