

A Study on People's Awareness of Earthquake Early Warning before and after the 2011 off the Pacific Coast of Tohoku Earthquake, Japan



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SUMMARY:

After the 2011 off the Pacific Coast of Tohoku Earthquake on March 11, 2011, Earthquake Early Warning (EEW) was frequently provided. However, some of the warning at aftershocks failed to estimate intensity properly due to technical limitation. In this paper, questionnaire surveys were conducted to understand people's awareness of EEW before and after the 2011 off the Pacific Coast of Tohoku Earthquake and change of their awareness was analyzed comparing both results. Their behavior after receiving the warning was also analyzed and suggestions for enhancing their capacity to take proper actions after EEW were obtained.

Keywords: Great East Japan earthquake, early warning, awareness, capacity building, questionnaire survey

1. INTRODUCTION

The Japan Meteorological Agency (JMA) began to provide the service of earthquake early warning (EEW) to the public on October 1, 2007. This is a new system that quickly analyses seismic wave data observed by seismographs near the epicenter and provides prompt alerts before the arrival of strong tremors (S-waves) as shown in fig.1. For public use, EEW is provided to the regions where the intensity of shaking was expected to be greater than JMA 4 in case the maximum estimated intensity is 5 lower. This system aims to mitigate earthquake-related damage by enabling individuals to protect themselves quickly in various environments such as houses, offices and factories. A warning is widely broadcasted by television, radio, mobile phone and loudspeakers.

The Iwate-Miyagi Inland Earthquake occurred in the southern inland region of Iwate Prefecture, Japan at 8:43 JST, June 14, 2008. It was the first earthquake since October 2007 for which EEW could be successfully broadcasted before the arrival of strong tremors. The lead time between the warning and the arrival of strong tremors was around 10-25 seconds in the area surrounding its epicenter. After this, a small earthquake occurred in Fukushima Prefecture at 16:59 JST on September 29, 2010. EEW was broadcasted in the eastern area of Japan as the expected intensity exceeded 4. It was broadcasted also in the Tokyo metropolitan area although observed intensity was less than 4. Recently, the percentage of the people who can get EEW by mobile phones is increasing. At this earthquake, a lot of people received the warning by mobile phone in the Tokyo metropolitan area for the first time and it became a good opportunity for making people familiar with EEW.

The 2011 off the Pacific Coast of Tohoku Earthquake occurred at 14:46 JST on March 11, 2011 and numerous aftershocks continued. EEW was successfully provided in Tohoku area at the main shocks. On the other hand, in the Tokyo metropolitan area, EEW failed at the main shock but was frequently announced at aftershocks. Figure 2 shows the number of EEW that was provided to each prefecture in Japan during March 2011 and April 2012. 45 warnings was provided in March. The number of broadcasted EEW from March 2011 to August 2011(6 months) was 87 although that number from October 2007 to February 2011(41 months) was 17. However, some of the numerous warning at aftershocks failed to estimate intensity properly because several earthquakes occurred at the same time

could not be identified separately or some seismometers were unusable due to long-time power outage after the earthquake. These problems were due to technical limitation of EEW and some of them were solved by program modification after March 2011.

In this paper, two questionnaire surveys were conducted to understand people's awareness of EEW. The first one was done after the earthquake in September 2010 for the people who received the warning by mobile phone. The second one was done after the earthquake in Tohoku region in March 2011. The change of their awareness was analyzed comparing both results. Their behavior after receiving the warning was also analyzed and suggestions for enhancing their capacity to take proper actions after EEW were obtained.

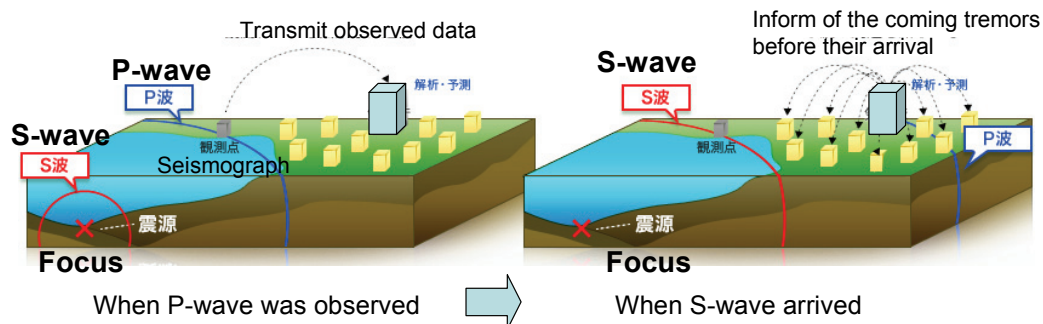


Figure 1. Concept of Earthquake Early Warning

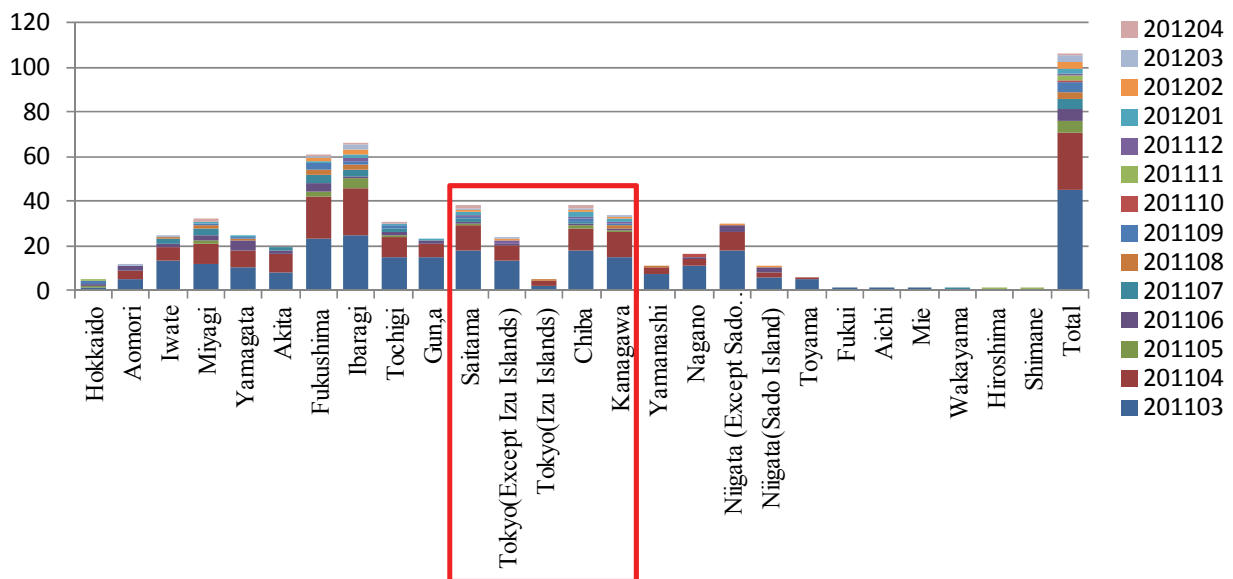


Figure 2. Number of Earthquake Early Warning Provided to Each Prefecture during March 2011 and April 2012.

2. OUTLINE OF TWO QUESTIONNAIRE SURVEYS

The first questionnaire survey was done after the earthquake in Fukushima Prefecture on September 29, 2010. Survey period was from November 5-11, 2010. Main target of the survey was the people with 30-60's living in the Tokyo Metropolitan area (Tokyo, Saitama, Chiba, Kanagawa Prefectures) who received the warning by their own mobile phone or neighbor's mobile phones. The number of respondents in each group was shown in table 1.

The second survey was done after the earthquake in Tohoku region in March 2011. Survey period was from August 9-16, 2011. A questionnaire sheet was sent to the same respondent as the first survey. The number of EEW that was provided to Tokyo, Saitama, Chiba Kanagawa Prefectures was shown

within red line in fig. 2. The total number of EEWs in Tokyo(Except Izu Islands), Saitama, Chiba Kanagawa Prefectures from March 2011 to July 2011(5 months) were 21, 32, 31, 28, respectively. The ratio of the respondents who answered the second survey was 76.6%(613 people among 800). The number of the group A respondents who answered the survey in 2011 was 153. Among them, 11 people changed their mobile phones and could not receive EEW as of March 2011. The number of the respondents in each group who answered the survey in 2011 and could receive EEW as of March 2011 was shown in table 1.

Table 1. Number of respondents for surveys in 2010 and 2011

	2010 Survey	2011 Survey					Ratio of the respondents who answered the second survey	
		Could receive EEW by mobile phone as of March 2011			Could not receive EEW by mobile phone as of March 2011	total		
			Received at home after march 2011	Received outside home after march 2011				
A	Received EEW by their own mobile phones	200	142	118	91	11	153	76.5
B	Received EEW by their neighbors' mobile phones	200	70	48	42	81	151	75.5
C	Received EEW by their own mobile phones and experienced the stop of train	200	119	65	52	31	150	75
D	Didn't receive or listen EEW	200	71	49	36	88	159	79.5

3. RESPONDENTS' KNOWLEDGE OF EARTHQUAKE EARLY WARNING

At first, change of respondents' knowledge of EEW was analyzed comparing the results of two surveys. All the groups had the same tendency between 2010 and 2011. Figure 3 shows the result of group A for example. After the earthquake in September 2010, 50.3% knew both the name of EEW and that it forecast a strong tremor just before its arrival. After the experience of the main shock and aftershocks of Tohoku earthquake in 2011, the ratio increased to be 89.5%. At the survey in 2011, the respondents who knew neither its name nor its meaning were drastically decreased to be 2.0%.

Figure 4 shows the respondents' knowledge of methods or conditions of EEW broadcasting. It is a result of group A for example as all the groups had the same tendency between 2010 and 2011. The ratio of the respondents who knew that EEW is broadcasted on TV or by mobile phone increased after 2010 and exceeded 90% in 2011. On TV, the name of the area where strong tremors are expected and the warning message are shown. On the other hand, neither expected intensity nor lead time before the arrival of strong tremors is explained. The knowledge on expected intensity or lead time was low in 2010 but increased especially in 2011. However, knowledge of criteria on intensity at which EEW is broadcasted was still low. In addition, change in the knowledge of special receiving devices was very small although the special receiving devices are important tools for receiving expected intensity or lead time at home. Enhancing these knowledges is necessary.

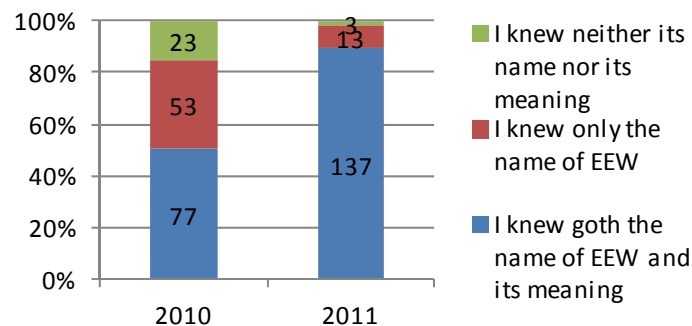


Figure 3. Respondents' knowledge of EEW

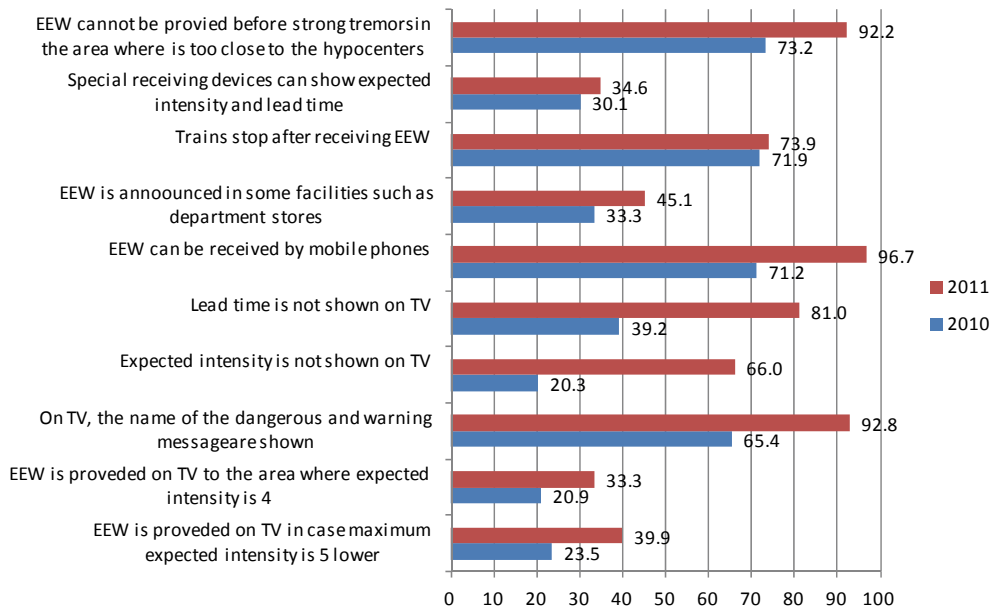


Figure 4. Respondents' knowledge of methods or conditions of EEW broadcasting

4. RESPONDENTS' RESPONSE TO EARTHQUAKE EARLY WARNING

Next, respondents' response to EEW after EEW was investigated. More than 80% of each group watched EEW on TV at home after March 2011. The ratio of the respondents who received EEW at home was highest in group A. 88.4% of group A watched EEW on TV and 80.3% received by mobile phone at home. 59.4% received by mobile phone outside home. The feeling of respondents in group A after receiving EEW at home was investigated. Figure 5 is the comparison of their feeling after earthquakes in 2010 and 2011. The ratio of the respondents who thought that strong tremor would come soon drastically increased from 34% to 86.7%. It shows that experience of receiving many EEW after March 2011 led to high awareness of warning message.

Figure 6 shows what respondents in group A did immediately after receiving EEW at home at the both earthquakes. Most frequent response after both earthquakes was to get earthquake information from television or radio. The second one was to wait. The ratio of the response for informing their children or people near them was drastically increased from 2010 to 2011. The ratio of holding furniture or valuables, hiding in a safe place and protecting my body, protecting children or elderly people, opening a door or window were also increased in 2011. The aim of EEW service is to enable residents to quickly protect themselves before the arrival of strong tremors. Considering this aim, it is said the experiences of receiving many EEW after March 2011 enhanced their capacity to take actions for protecting themselves or family members.

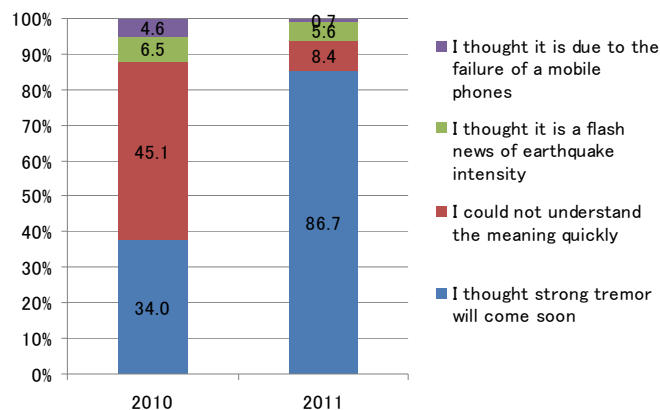


Figure 5. Respondents' feeling after receiving EEW

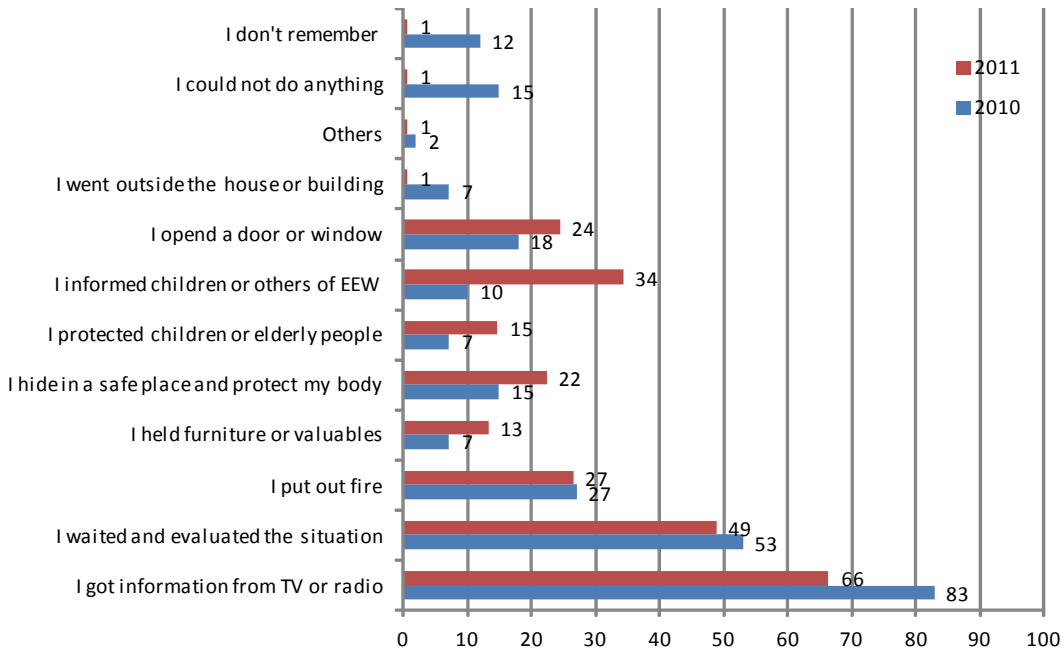


Figure 6. Ratio of Respondent's action after receiving EEW

5. RESPONDENTS' ATTITUDE TOWARD FAILURE OF EARTHQUAKE EARLY WARNING

After the earthquake on March 11, 2011, numerous EEW was provided to the public due to continuous aftershocks. However, some of them failed to estimate intensity properly because several earthquakes at the same time could not be identified separately or some seismometers were unusable due to long-time power outage after the earthquake. These problems were due to technical limitation of EEW and were announced beforehand by Japan Meteorological Agency. Here, the knowledge of technical limitation before the earthquake and their attitude toward the failure of EEW were analyzed. 36.5% of the respondents among all knew the technical limitation before March 2011 that actual intensity can be more or less than the expected intensity within the range of intensity 1. About 90% of the respondents wished to use EEW even if it has a risk of failure regardless of whether they knew technical limitation before the earthquake or not. 55.4% of the respondents with the knowledge of technical limitation answered that they would like to use EEW aggressively even if they have a risk of failure. The ratio decreased to be 35.0% without the knowledge. It was verified that familiarization with technical limitation before the event is important in order to increase positive attitude in case that EEW fails.

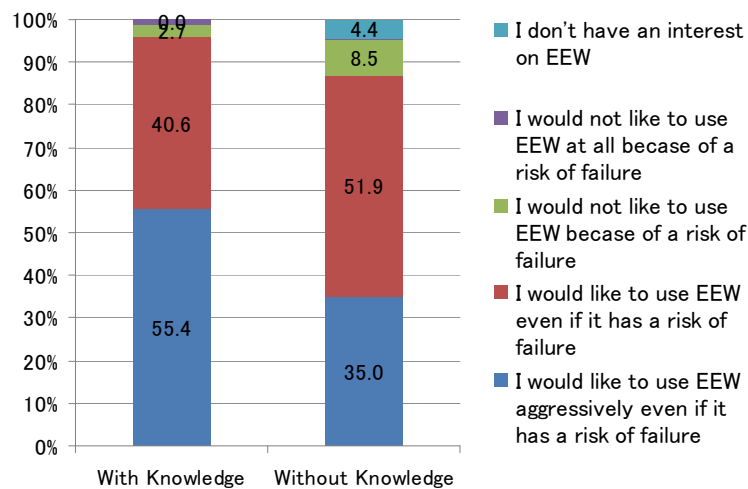


Figure 7. Respondents' attitude toward failure of EEW

6. RESPONDENTS' OPINION ON EFFECTIVENESS OF EARTHQUAKE EARLY WARNING

Finally, their opinion on effectiveness of EEW was investigated. The ratio of the respondents who thought EEW was very effective for mitigating seismic damage was about 40% at the both survey in 2010 and 2011. Including the respondents who thought it is effective, the total ratio of positive respondents amounted to be about 90%. When we focused on the relationship between their opinion and the experience of receiving EEW after March 2011, the ratio of the respondents who thought to be very effective was 38.5% as shown in fig.8. It was verified that real experience of receiving EEW enhanced the understanding of effectiveness of EEW. Figure 8 is the relationship between their opinion and the knowledge on technical limitation before the earthquakes. In the chapter four, we found that familiarization with technical limitation before the event increased positive attitude toward the failure of EEW. In fig. 9, the ratio of the respondents who thought to be very effective was 54.5% in case they had knowledge on technical limitation before the earthquake. This value was almost twice of the ratio in case of respondents without the knowledge. It is concluded that making people familiar with technical limitation led to their positive attitude toward EEW and it can increase high evaluation on the effectiveness of EEW.

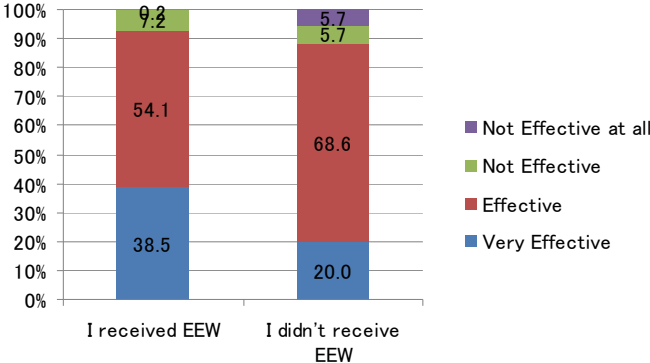


Figure 8. Relationship between understanding of effectiveness and the experience of receiving EEW

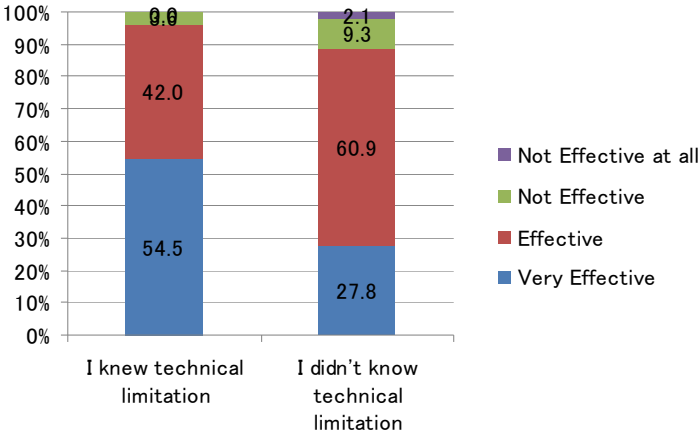


Figure 9. Relationship between understanding of effectiveness and the knowledge on technical limitation

7. CONCLUSIONS

In this paper, two questionnaire surveys were conducted to understand people’s awareness of EEW. The first one was done after the earthquake in September 2010 for the people who received the warning by mobile phone. The second one was done after the earthquake in Tohoku in March 2011.

The change of their awareness was analyzed comparing both results.

After the experience of the main shock and aftershocks of Tohoku earthquake in 2011, knowledge of EEW among residents drastically increased. Some of the knowledges were low still in 2011 and required to be enhanced. Their behavior after receiving the warning was also analyzed. The ratio of the respondents who thought that strong tremor would come soon drastically increased from 34% in 2010 to 86.7% in 2011. It shows that experience of receiving many EEW after March 2011 led to high awareness of warning message. In 2011, the ratio of the response for informing their children or people near them, protect their bodies, protect their children or elderly family members increased, compared with the answers in 2010. The experiences of receiving many EEW after March 2011 enhanced their capacity to take actions for protecting themselves or family members. People's awareness level and capacity can decrease easily as time passes after the disaster. It is very important to keep their awareness level by education or training in the future.

After the earthquake on March 11, 2011, numerous EEW was provided to the public due to continuous aftershocks. However, some of them failed to estimate intensity properly due to technical limitation. From the survey, familiarization with technical limitation before the earthquakes increased positive attitude in case that EEW failed. It also increased high evaluation of the effectiveness of EEW. Continuous information dissemination on technical limitation is important for positive attitude for taking action after receiving EEW.

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