

Interviewing insights regarding the high fatality rate inflicted by the 2011 Tohoku earthquake

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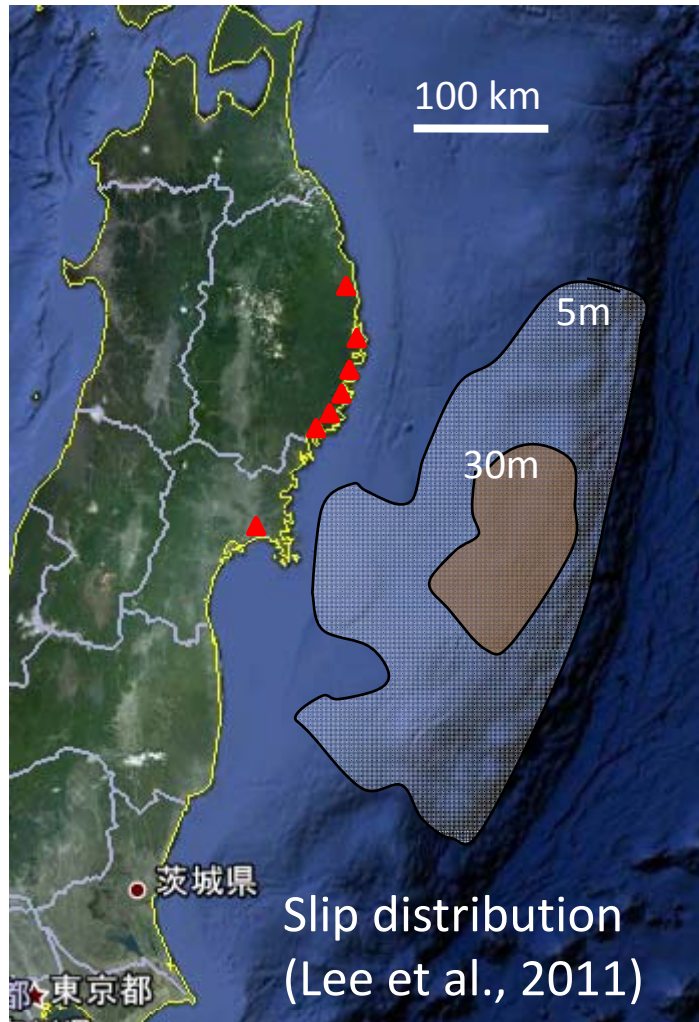
- We thank many interviewees agreed to be interviewed despite the hardships at evacuation shelters.

- Coauthors



Interviewing areas

Deeply indented coastline



Highlands in most of the interview areas are within 10-20 minute walking distances.



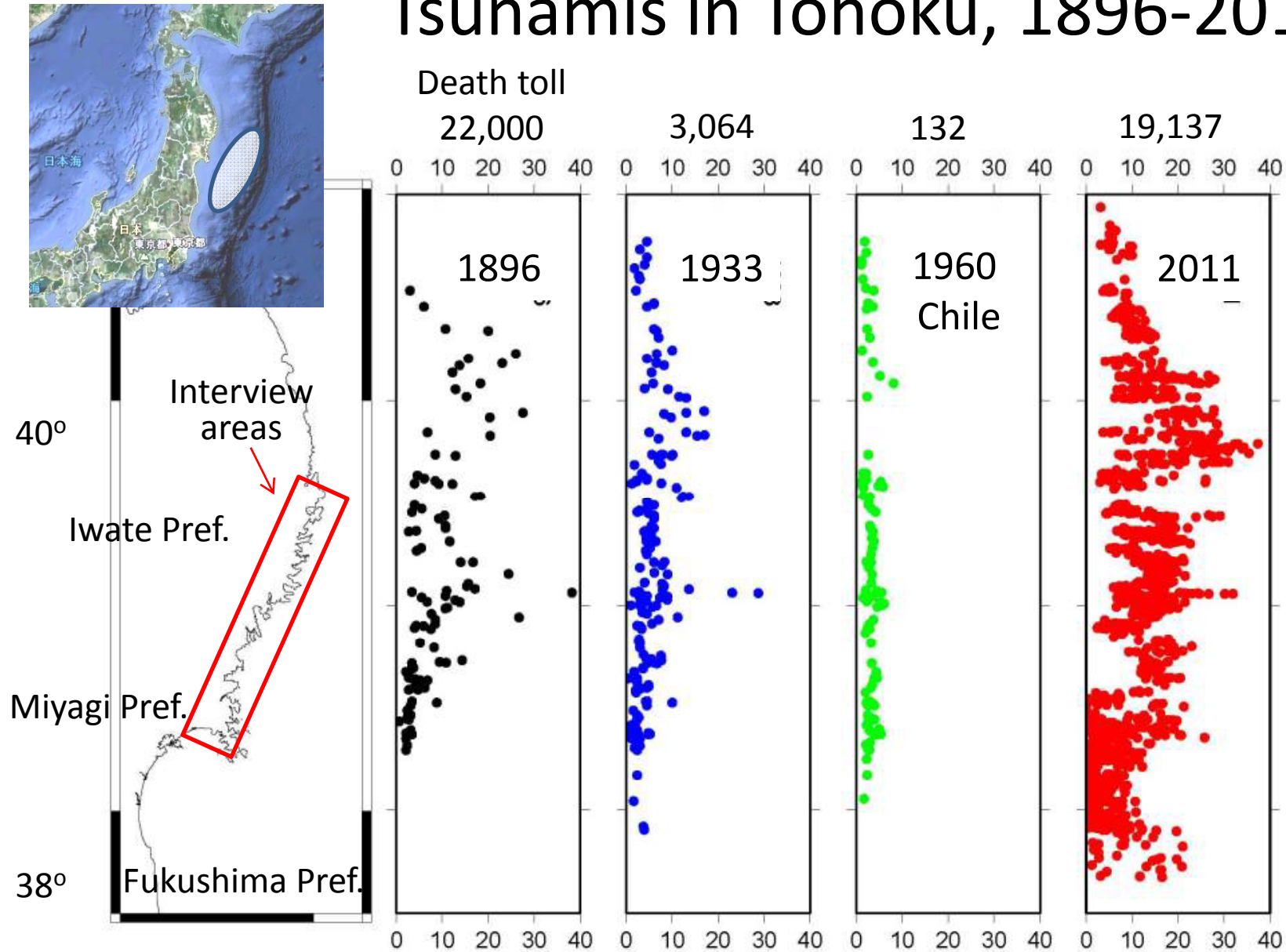
Tsunami preparedness in Tohoku

- **Three tsunamis** in the 115 years.
- **Preparedness of structural measures:**
breakwaters, evacuation stairways
shelters, communication systems along the entire
northeastern coasts.
- **Preparedness of non-structural measures:**
Hazard maps, tsunami evacuation drills

The objective of our interview

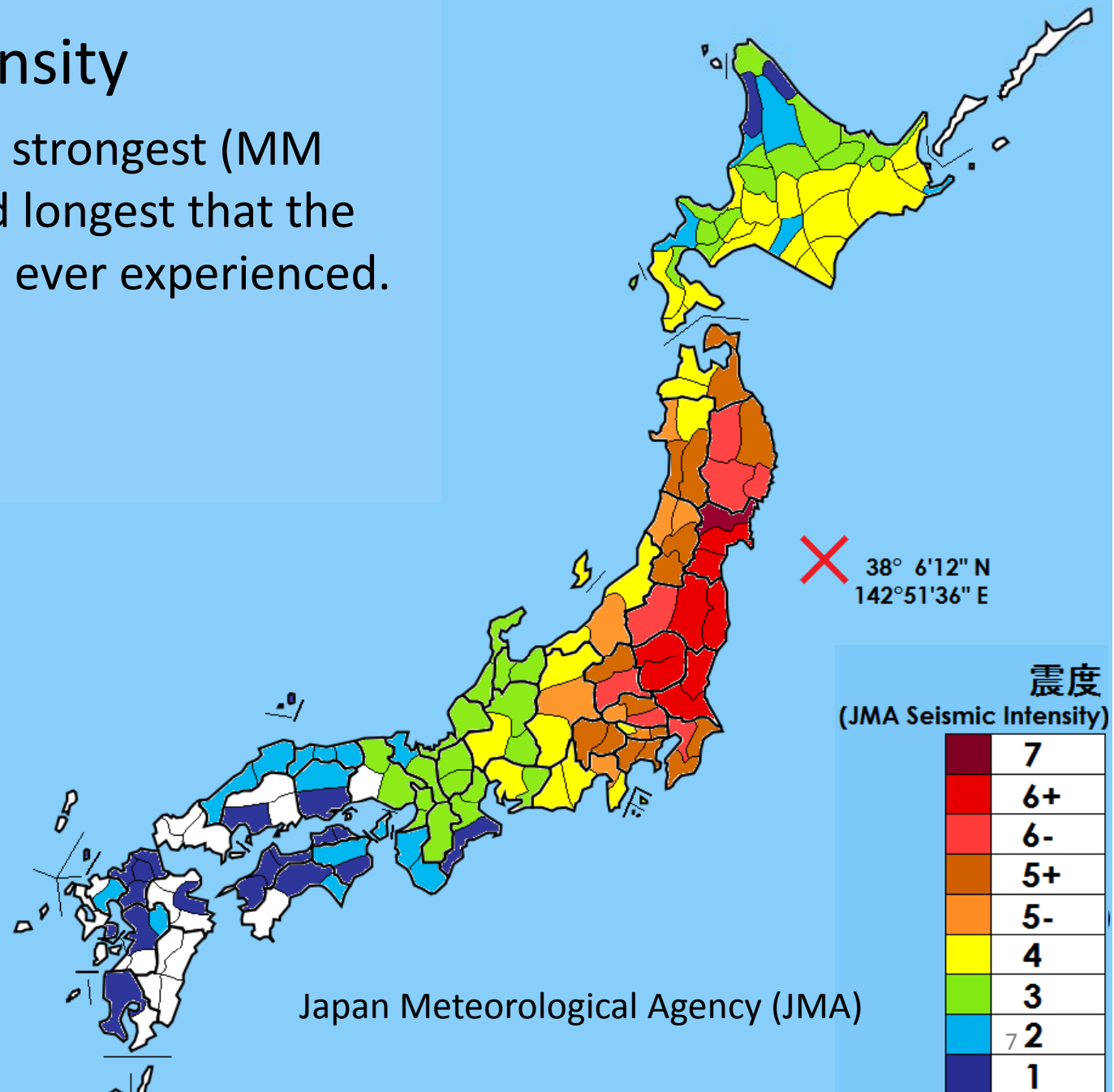
- Despite these preparedness efforts, the March 11 Tohoku earthquake caused numerous fatalities.
- To find out the reasons, 156 tsunami survivors at evacuation shelters in 7 cities were interviewed in mid-April and late May.
- Interviews for about 30min, focused on behaviors and those that they had observed

Tsunamis in Tohoku, 1896-2011



Seismic intensity

The shaking was strongest (MM scale IX - XI) and longest that the local people had ever experienced.



Ofunato city



Miyako city



A shopping street in Kamaishi city



A shop's interior in Kamaishi

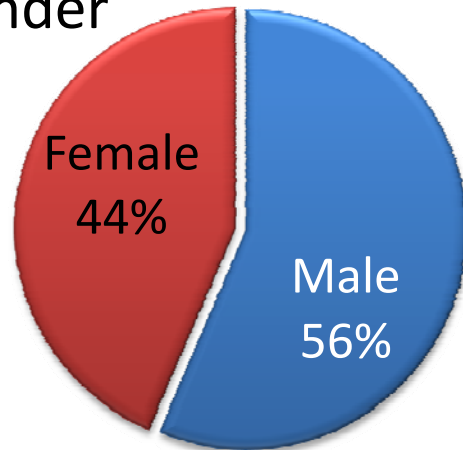


One of the evacuation shelters the gymnasium of a middle high school

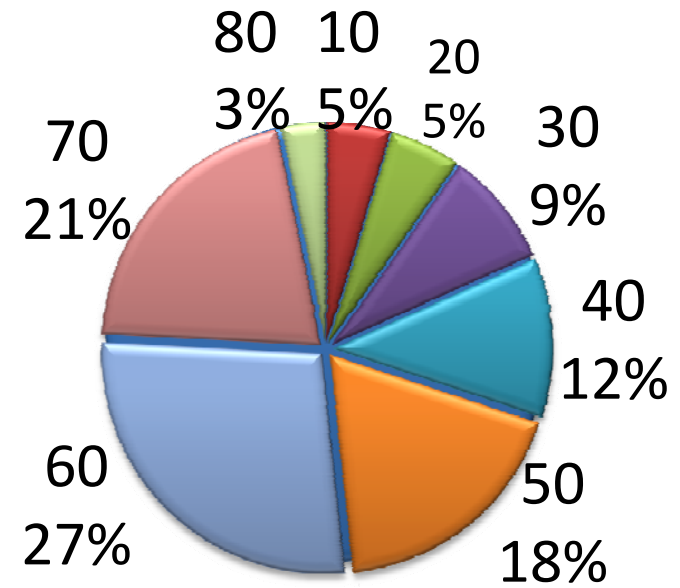


156 interviewees

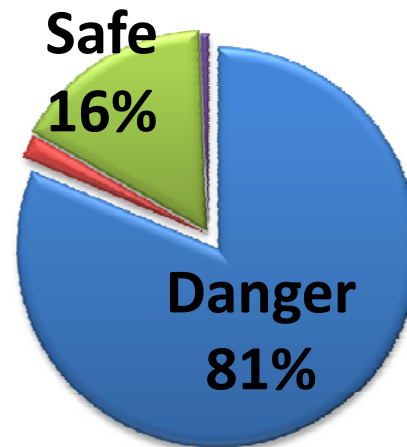
Gender



Age distribution



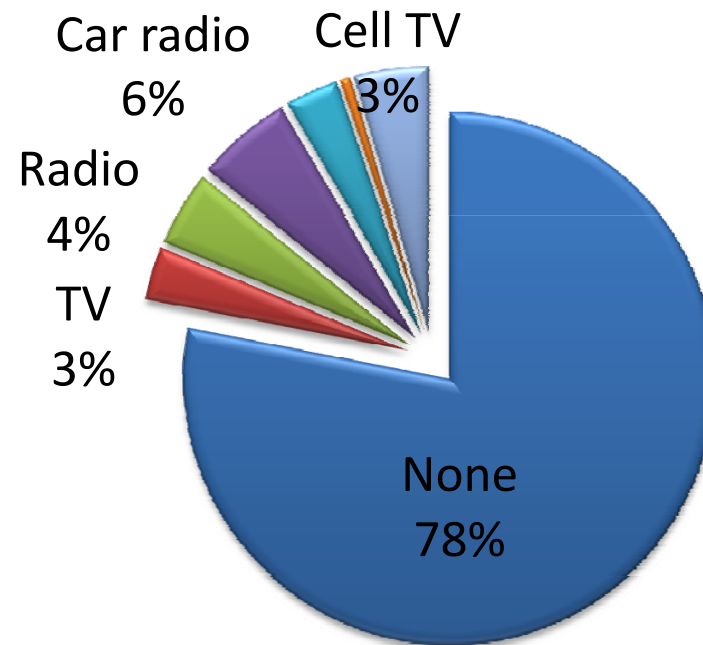
Where were the interviewees when the earthquake hit?



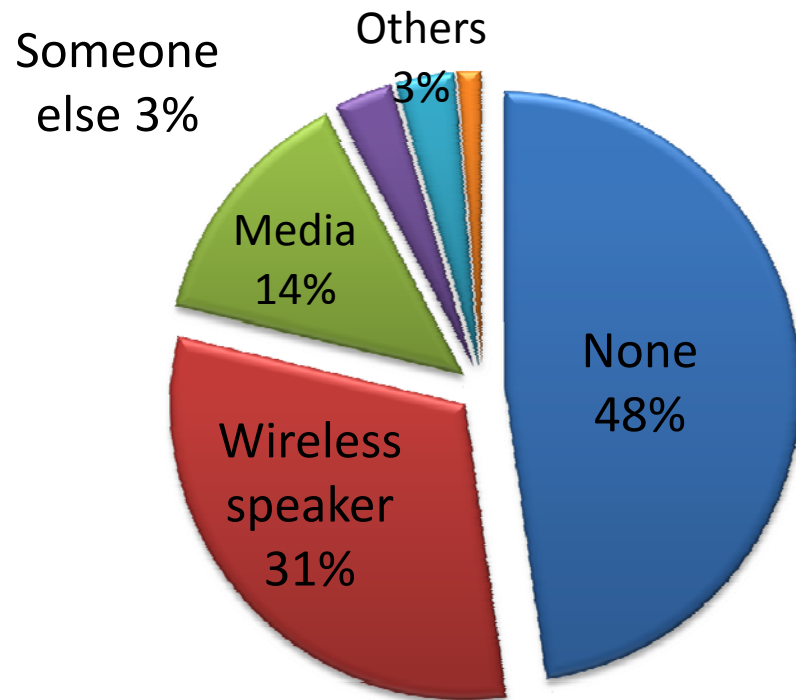
What caused the large number of casualties?

Power supplies stopped immediately after the strong ground shaking started.

- People were unable to get the tsunami information through TV, but were able to access to the radio. However, the ratio of listening to the warning from the radio was quite low, 10 %.



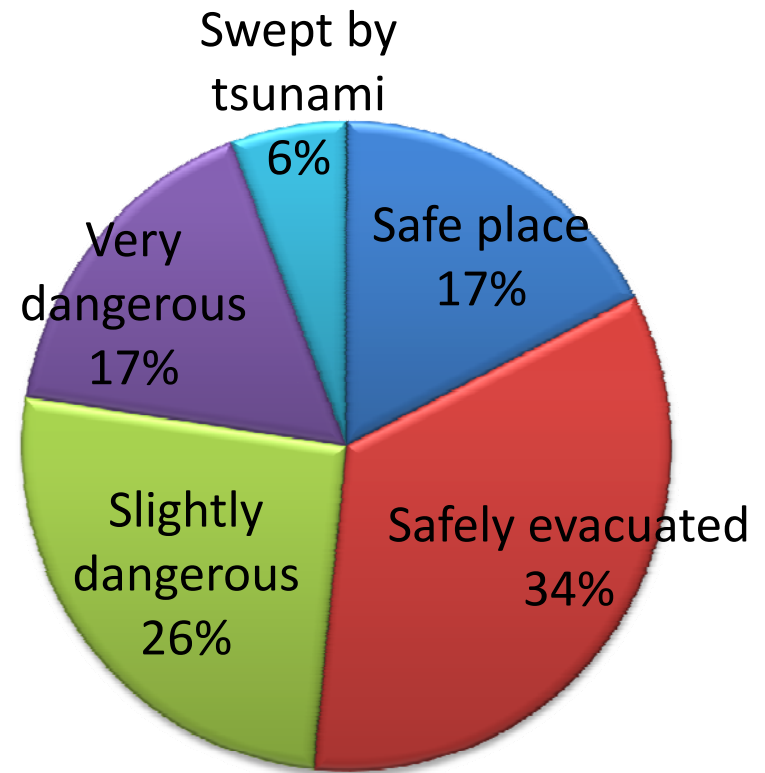
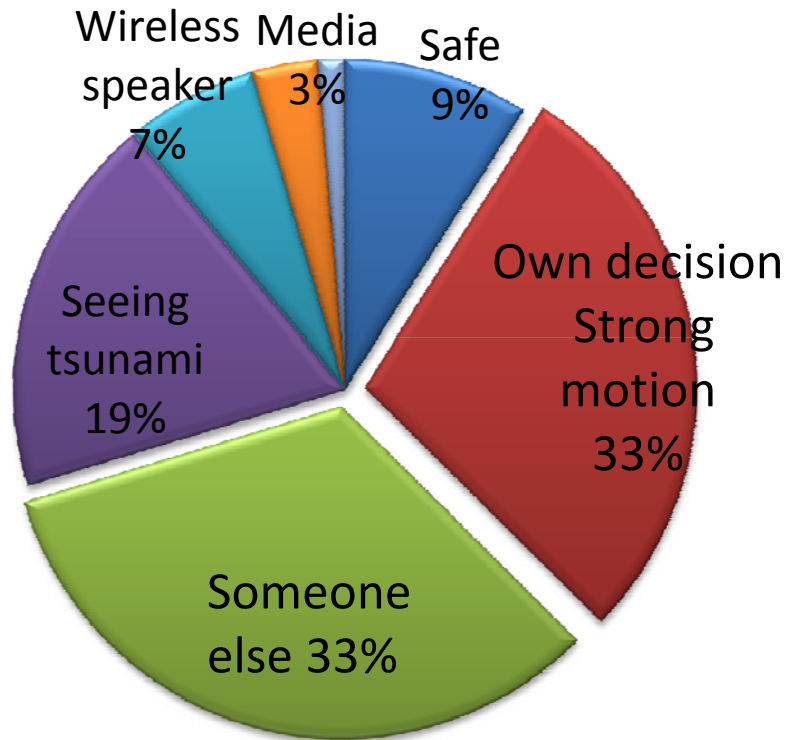
How did the residents get the tsunami warning issued?



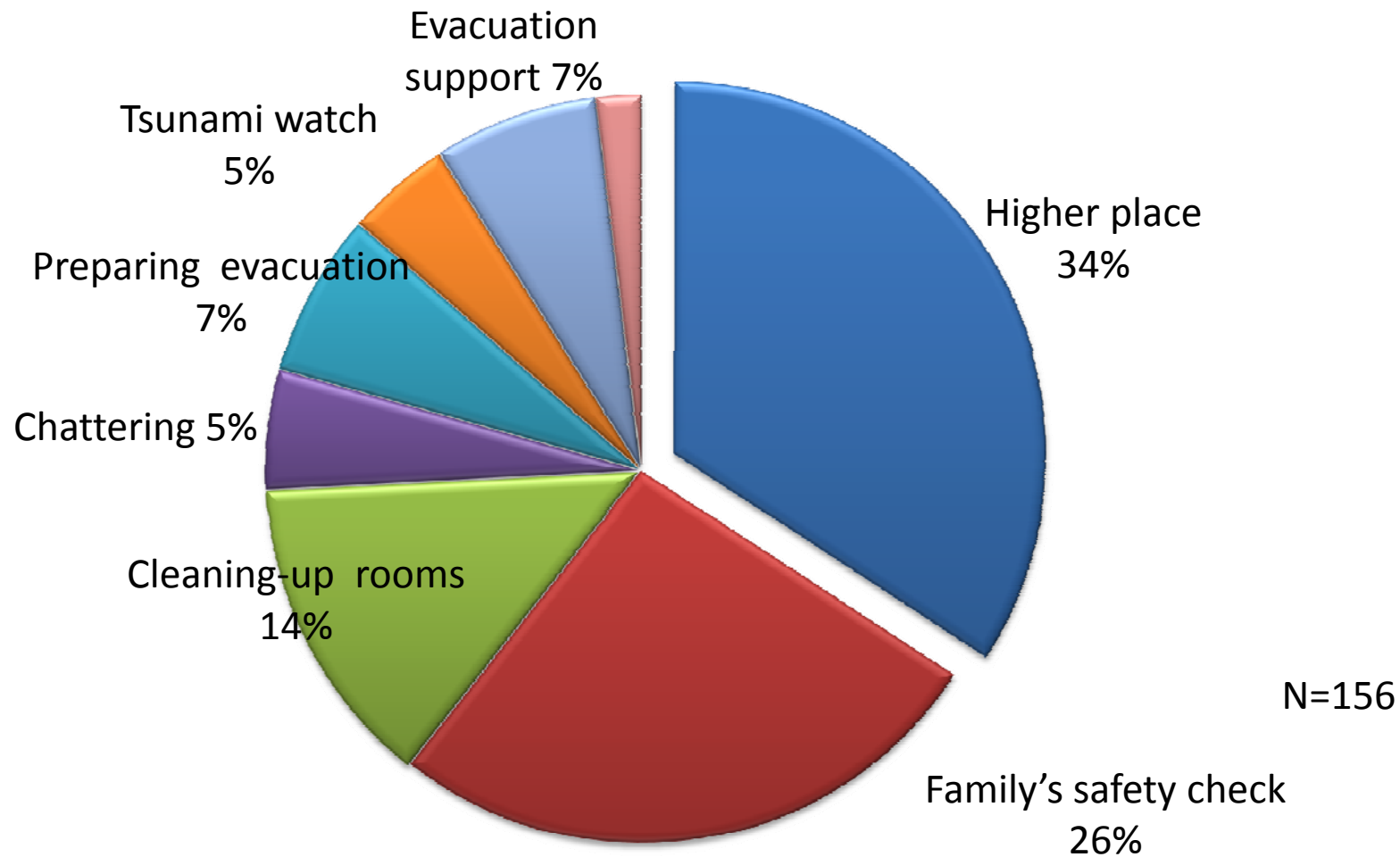
“Bosai Musen” (防災無線)

- Wireless outdoor loud speakers operated by battery
- Broadcasted from the local municipal offices
- Installed at most communities.
- Used for everyday public information to local communities

Decision to evacuate



What did the residents do after the stop of strong shaking

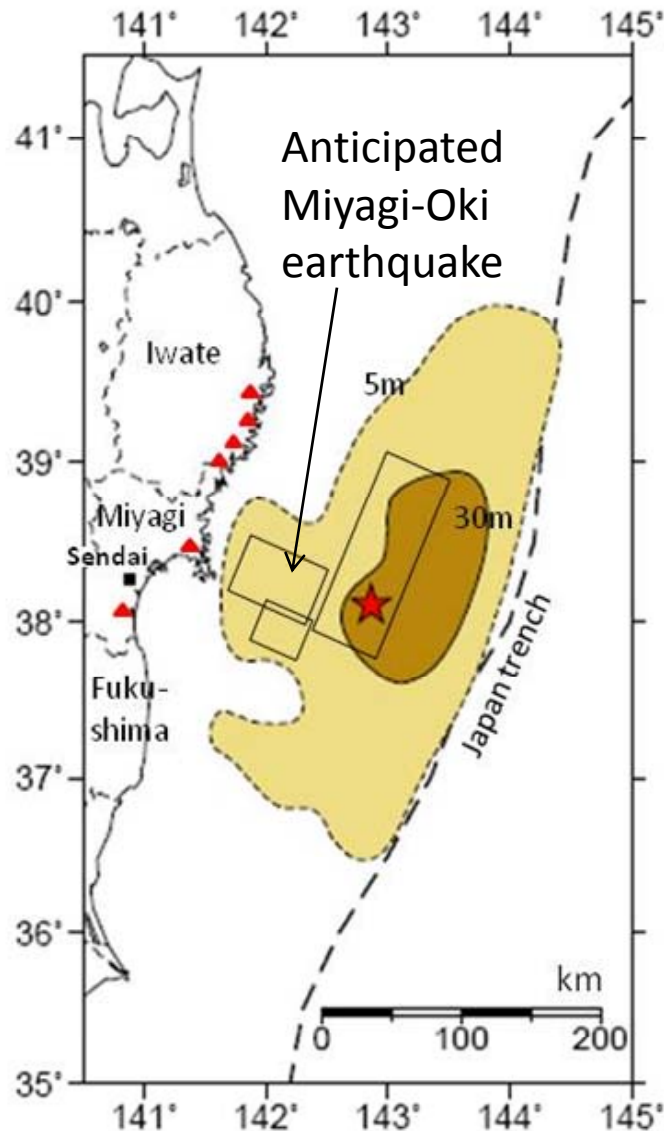


Results of interviews

The residents' decisions not to evacuate immediately is partly due or influenced by current earthquake science research results.

1. Incorrect long-term forecast
2. Insufficient tsunami warning
3. Insensitiveness to the JMA repeating warnings
4. Breakwaters gave a false sense of security
5. Experience of the Chile 1960 tsunami
6. Others

1. Incorrect long-term earthquake forecast



- Many evacuation shelters were located based on the **risk assessments**. Consequently, many people evacuated initially into these designated evacuation sites but eventually **evacuated again** after seeing the height of the incoming tsunami.
- A city councilman said he regretted some **evacuation shelters** in the town were built based on the assessment of tsunami inundation heights according to the anticipated “**Miyagi-Oki earthquake**”.

2. Insufficient warning issued by JMA

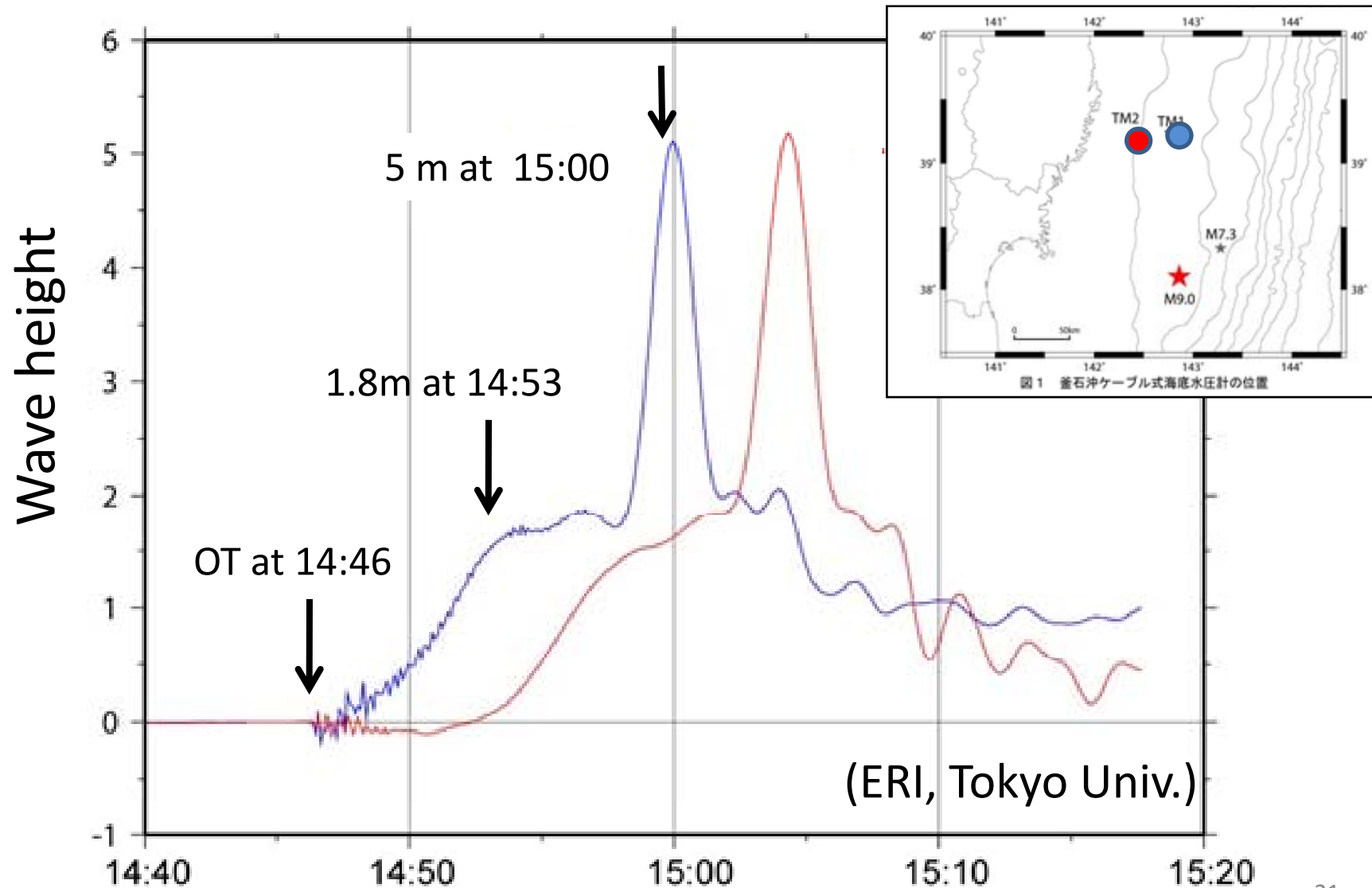
- The first determination M7.9
- Predicted inundation heights 3 m in the interview areas
- the final tsunami warning to residents.

Examples

Some people went to **see the incoming to harbors.**

“It could be **safe to stay at home**“ since the neighboring breakwater is 4m high and the incoming tsunami is only 3m.
(20 out of 76)

Cabled ocean bottom pressure gage records were not used



3. Insensitiveness to the JMA repeating warnings

The warnings below had experienced only small or even negligible tsunamis. These frequent warnings with overestimated tsunami height influenced the behavior of the residents. (28 out of 76)

2007	2008	2009	2010
Peru, Mw8.0 22cm, 12h	Tokachi, Mw6.7 18cm, 1.5h	Samoa, Mw7.9 36cm, 6h	Chile Mw8.5 106cm, 24h
Sakhalin, Mw6.2 0cm, 0.8h	Fukushim, Mw6.9 23cm, 1.5h	Okinawa, Mw6.2 0cm, 0.6h, SS	Okinawa, Mw7.0, 13cm, 1.5h, SS
Niigata, Mw6.7 32cm, 1h		Okinawa, Mw6.6 0cm, 0.9h, SS	Okinawa, Mw6.5 0cm, 1h, SS
Okinawa, Mw6.4 0cm, 1h		Shizuoka, Mw6.5 36cm, 1h, SS	
Noto, Mw6.6 22cm, 2h		New Guniea, Mw7.6 36cm, 5.5h	
Kurile, Mw8.1 43cm, 8.5h			

4. Breakwaters

- Some inhabitants assumed that the 2.5- to 6-meter-high breakwaters would protect their localities.
- Only slight flooding would occur and moving to the second floor at home was sufficient.



The anticipated maximum height is 50 cm in the inner part of the Kamaishi bay due to the breakwater built at the bay mouth, 60m high above the sea bottom (Ministry of Construction and Transportation)

5. 1960 tsunami from Mw9.5 Chile earthquake



This sense of “knowing” that “the tsunami will be small” based on their previous experience put their lives at very high risk. (61 out of 151)

[Photos from](#)

http://heirinzi.blogspot.com/2011/03/blog-post_9377.html

http://www.47news.jp/news/photonews/2009/05/post_20090523083731.php

Summary

- The current earthquake technology and science were not used efficiently for reducing the number of fatalities in the March 11 earthquake.
- Better knowledge regarding earthquakes and tsunami hazards could save more lives.
- To avoid similar high tsunami death rates in the future, residents including young children should be taught the basic mechanism of tsunami generation.

How to reduce tsunami casualties

- Considering the little information that the local inhabitants had received, the highest death rate is less than 20% even in the totally inundated areas .
- Eventually more than 80% of local people even in severe inundation areas were able to evacuate on time.
- Evacuate as soon as possible to higher places where tsunamis will not reach is the best measure to reduce the tsunami victims.

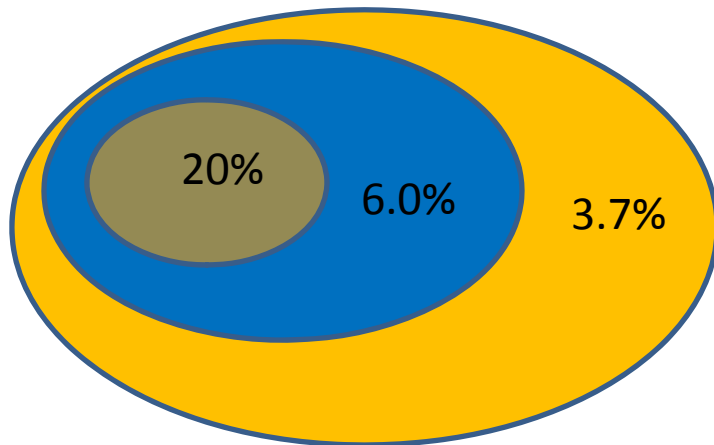
Supplementary

Our question

- many people in the devastated zones affected by the tsunami evacuated to safety, but others were not so fortunate.
- Why did some people evacuate immediately others wait until it was too late?
- In interviews with survivors, we sought to find answers to that question.

Fatality rates

- Average fatality rate in inundation population (Statistical Bureau): 3.7%
- Average fatality rate in severely damaged areas: 6.0%
- Highest fatality rate in severely damaged areas 20%



NEP: Number of people who had to evacuate immediately.

$$NEP = NH \times NF$$

NH: Number of totally destroyed houses

NF: Number of average family member



Human behavior in tsunami evacuation

- Residents are unwilling to evacuate since they believed tsunamis rare.
- Many residents started evacuating after seeing or knowing tsunami approaching.
- Many cars were used for evacuation: which were sometimes effective, but at many cases caused fatal traffic jams.

If the earthquake happened at night

- Most survivors said that they could **not be as safe** and lucky.
- On 311, snow and sleet fell in the devastated areas. Under the **power blackout**, navigating through the streets and the uphill climb would have been extremely hard and difficult.
- **Night time** occurrence could have prompted more people to **use their cars** to evacuate, which could have resulted in a much more significant death toll.

Time sense under pressured conditions

- There was 30 + min for evacuation after the major shaking stopped.
- However, many survivors said “we had only 10 to 15 min. “
- People did not take note of the time.

A city official working at a community center located at highlands

- Outside Bosai Musen was broadcasting the tsunami warning.
- The anticipated height was announced as 3m.
- The neighboring breakwater is higher than the incoming tsunami.
- Some people were waiting on the breakwater or chattering on the road.
- He was wondering the people had never seen their hazard map?
- People evacuated to the center, but the tsunami did not come yet.
- One person left for getting valuable articles at home.
- Then, one by one people leaving for their homes to get valuable articles as well. He was unable to stop them leaving.
- 30 min after the stop of strong ground motions, a big tsunami wave was approaching the coast.
- The people left never came back to the center.