Paper:

A Study on the 2016 Kumamoto Earthquake: Citizen's Evaluation of Earthquake Information and Their Evacuation and Sheltering Behaviors

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In order to reveal the current status and issues of the victims of the 2016 Kumamoto Earthquake eight months after its occurrence, we conducted large-scale random sample questionnaire surveys with victims aged 18 and over in the most affected municipalities from November to December 2016. We decided to sample a total of 7,000 victims (1,600 from Kumamoto City and 5,400 from the other thirteen municipalities) with an expected collection rate of 25% and a sampling error of 5%; 3,272 victims effectively responded to the questionnaires (effective collection rate: 46.7%). The Kumamoto Earthquake was a series of earthquakes including foreshocks and main shocks of magnitude 7 on the Japanese seismic intensity scale, and aftershocks that appear to have significantly influenced the victims' response behaviors as well as the recovery and reconstruction of the affected areas.

The questionnaire survey on whether the victims' pre-earthquake knowledge and awareness had any influence on their post-earthquake behaviors reveals that not more than 30% were aware of the active faults present in their areas before the earthquake occurred and that half of them hoped that no earthquakes would occur. On the other hand, the victims who were aware of the active faults present in their areas and who were afraid that an earthquake could occur within 10 years had planned accordingly and had stocked the necessary goods and provisions.

The questionnaire survey on how the victims behaved in the event of the foreshocks and main shocks reveals that about half of them evacuated and found shelter after the foreshocks. Those who feared any aftershocks, and the damage to their buildings due to the aftershocks, evacuated and took shelter. Those whose buildings were not damaged and whose lifelines were available did not evacuate or take shelter. After the main shock, about 70% of the victims evacuated and took shelter because, in addition to their fears of the aftershocks, their buildings were actually damaged and their lifelines had been rendered unavailable.

The questionnaire survey on whether the victims' pre-earthquake knowledge and awareness had any influence on their post-earthquake behaviors reveals that in the event of an earthquake, like in the case of the foreshocks of the Kumamoto Earthquake in which human beings and buildings were not so scathed and people could not decide whether to evacuate or take shelter, those with more pre-earthquake knowledge and with awareness of earthquake damage better anticipated the aftershock occurrences. On the other hand, in the event of the main shocks of the Kumamoto Earthquake, in which there was great damage to humans and buildings, people with or without pre-earthquake knowledge and awareness on earthquake damage were urged to evacuate and take shelter.

The questionnaire survey on whether aftershock information was properly communicated to the victims reveals that they followed the information on aftershocks broadcast by TVs and radios immediately after the foreshock had occurred. The victims did not follow the Meteorological Agency's press release on the aftershocks on the afternoon of the following day in order to get an update. Instead, they took the information broadcast by TVs and radios as "no great aftershocks would occur in the future," which was completely different from what the Meteorological Agency's press release intended. The questionnaire survey on the influences of the aftershock information on the victims' evacuation and sheltering behaviors reveals that the Meteorological Agency's press release on the following day of the foreshock occurrence stated that the probability of the aftershock occurrence of lower 6 or over on the Japanese seismic intensity scale is 20% in the following three days, and that of the aftershock occurrence of upper 5 or over on the Japanese seismic intensity scale is 40%. This seems to have had a greater influence on the behaviors of the victims who assumed that "no great aftershocks would occur in the future" as compared to the behaviors of those who assumed that "an aftershock could occur anytime in the future" and "a big aftershock might occur in the future."

With regard to the movements in the victims' long-

term post-earthquake residences and evacuation destinations, 57.5% of the total victims stayed at home after the foreshock occurrence, which is not so different from the case of the Hanshin-Awaji (Kobe) Earthquake, an inland earthquake with relatively few aftershock activities. However, the ratio of the victims who stayed at home stood at 28.7% after the main shock occurrence, at 32.8% on the first weekend or about four days after the foreshock occurrence, and at 49% in the week following the earthquake occurrence, which indicates that more victims evacuated and sought shelter outdoors in cars, tents, and vacant grounds as seen in the case of the Mid-Niigata Earthquake, which witnessed many aftershock activities. Therefore, the evacuation behavior pattern in the Kumamoto Earthquake may be regarded as a cross between the Hanshin-Awaji (Kobe) Earthquake and the Mid-Niigata Earthquake.

Keywords: random sampled questionnaire survey, pre-earthquake awareness of local active faults, victims' post-earthquake evacuation and sheltering behavior, aftershock information

1. Study Background and Purpose

1.1. Characteristics of the 2016 Kumamoto Earthquake

The Kumamoto Earthquake that occurred in April 2016 caused great damage, leaving 247 people dead (50 as confirmed by the police autopsy, 192 by the municipalities' Acts for the Payment of Solatia for Disaster, and 5 by the earthquakes during the June 19 to 25 heavy rainfalls), 8,672 houses completely destroyed, 34,514 houses half-destroyed, and 161,923 houses partially destroyed (Fire Defense Agency, 2017) [1].

The characteristics of the seismic activities of the Kumamoto Earthquake lie in two occurrences of earthquakes of magnitude 7 on the Japanese scale: one occurrence called "foreshocks" (hereafter referred to as foreshocks) and the other called "main shocks" (hereafter referred to as main shocks). On April 14, at around 21:26 hours, an earthquake of magnitude 6.5, with a hypocentric depth of 11 km, occurred in Kumamoto District of Kumamoto Prefecture. It registered a magnitude of 7 on the Japanese scale in Mashiki Town of Kumamoto Prefecture and lower 6 on the Japanese scale in Kumamoto City, Tamana City, Uki City, Nishihara Village, and Kashima Town. On April 16, at around 01:25 hours, an earthquake of magnitude 7.3 with a hypocentric depth of 12 km occurred. It registered a magnitude of 7 on the Japanese scale in Masuki Town and Nishihara Village of Kumamoto Prefecture and upper 6 on the Japanese scale in Minami-Aso Village, Kikuchi City, Udo City, Otsu Town, Kashima Town, Uki City, Koshi City, and Kumamoto City (Meteorological Agency, 2016) [2]. Within a week of the April 14 foreshock, 21 earthquakes of lower 5 or over on the Japanese scale (foreshocks, main shocks, and aftershocks) occurred, out of which two had a magnitude of 7 on the Japanese scale, two of upper 6, three of lower 6, four of upper 5, and ten of lower 5 (each seismic intensity indicates the maximum seismic intensity, although some of them may not be clearly separated from others due to the influences of the earthquakes that occurred immediately before or after an earthquake), which outnumbers the 2004 Mid-Niigata Earthquake (Meteorological Agency, 2017) [3].

The above-mentioned characteristics of the seismic activities also significantly influenced the victims' evacuation and sheltering behaviors. Kumamoto Prefecture reviewed in 2016 that they had difficulty locating all the evacuees, particularly those who were sheltered in places other than the parking lots in designated shelters, such as in cars, tents, and home premises (not in their own houses but in sheds or cars on the premises.) With some shelters having no manuals and others left unused, residents rely much on their local governments to operate such shelters instead of operating them on their own, which is an issue to be addressed in the future [4].

1.2. Study Purpose

In the Kumamoto Earthquake, two occurrences of earthquakes of magnitude 7 on the Japanese scale took place and their aftershocks seem to have significantly influenced the victims' response behaviors, particularly their evacuation and sheltering behaviors, and recovery and reconstruction of the affected areas. In this study, we have conducted highly reliable and scientific random sample questionnaire surveys to reveal how the victims behaved in the event of the foreshocks and main shocks, whether the victims' pre-earthquake knowledge and awareness influenced their post-earthquake behaviors, whether aftershock information was properly communicated to the victims, how aftershock information influenced the victims' evacuation and sheltering behaviors, and how much of the affected areas were recovered and reconstructed from the earthquakes.

2. Methods

2.1. Survey Background

In this study, we have obtained data from the "Questionnaires on Aftershock Information and Evacuation and Sheltering Behaviors in the Kumamoto Earthquake" that was conducted by the Earthquake and Disaster-Reduction Research Division in the Research and Development Bureau of the Ministry of Education, Culture, Sports, Science and Technology (MEXT) from November to December 2016. As expert commission members of the Headquarters of Earthquake Research Promotion in MEXT, we have designed, prepared, and analyzed the questionnaire surveys on the basis of the previous large-scale random sample questionnaire surveys conducted in the event of past earthquake disasters (Kimura, 2007; Kimura et al., 2010, 2014, 2015) [5–8].

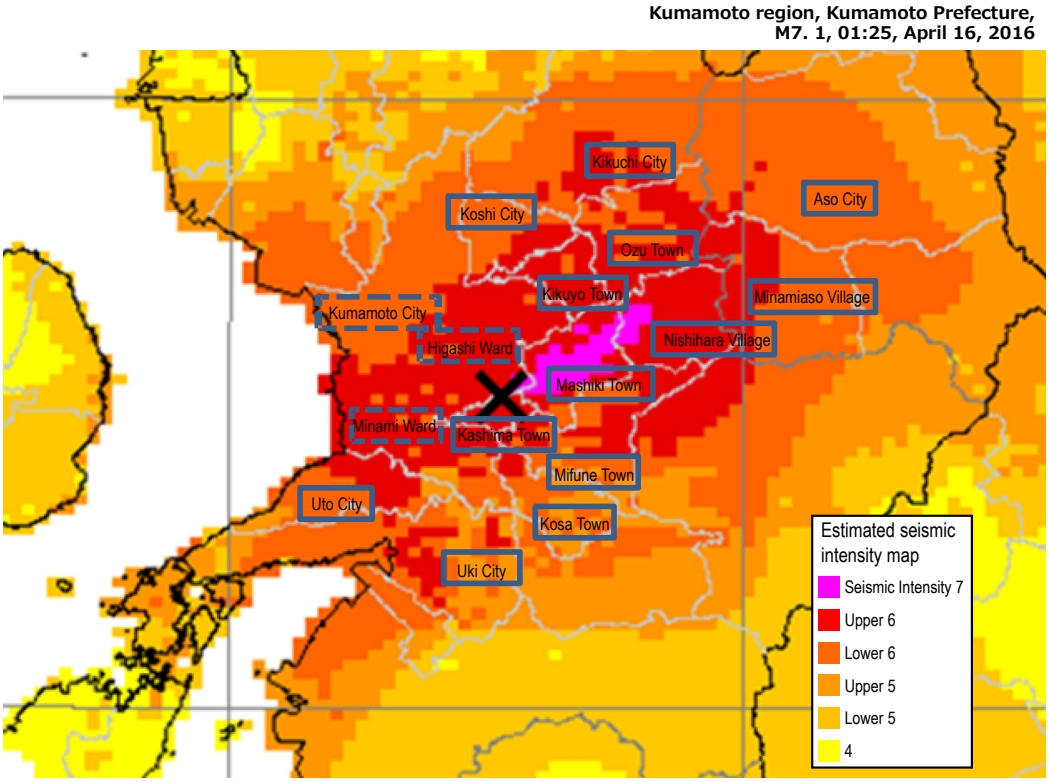

Fig. 1. Superimposition of the Estimated Seismic Intensity Map of the Japan Meteorological Agency.

2.2. How to Sample Survey Areas and Subjects

In the surveys, questionnaires are mailed to subjects who fill them and return the filled questionnaires by mail. The areas to be surveyed include fourteen municipalities that were intensively affected by the Kumamoto Earthquake. Each of the fourteen selected municipalities meets one or more of the following conditions: 1) its main shocks registered upper 6 or over on the Japanese scale; 2) the ratio of completely destroyed households is 10% or more (500 or more houses completely destroyed in each ward of the designated Kumamoto City); 3) the ratio of half-destroyed households is 20% or more; 4) the ratio of maximum evacuees in the population is 15% or more. In the designated Kumamoto City, East Ward and South Ward meet the above-mentioned conditions and are selected as survey areas. By looking at the Meteorological Agency's estimated seismic intensity distribution maps, we can see that the selected areas are where earthquakes of large seismic intensities occurred (**Fig. 1**) [9].

The survey subjects are male and female adults of age 18 or over, and are systematically sampled from the electorates' list or from the basic resident register. We have decided the number of sampled subjects to be 7,000 with a sampling error of 5% or less in the expected collection rate of 25%, where 1,600 were from Kumamoto City and 5,400 from the other thirteen municipalities. In the survey period, we sampled the subjects from October to November 2016 and conducted the surveys from November 28 to December 19, 2016. The number of effectively collected questionnaires is 3,272 (effective collection rate: 46.7%).

2.3. Survey Items

The questionnaire surveys contain a total of 37 questions covering the following eight items:1) personal attributes (age, gender, occupation, residence, residential status, etc.); 2) pre-earthquake awareness of local active faults and preparedness; 3) damage (human, building, etc.); 4) post-foreshock evacuation and sheltering behaviors and awareness of aftershock information; 5) post-main shock evacuation and sheltering behaviors and awareness of aftershock information; 6) evaluation of aftershock information sources; 7) post-earthquake residential movements; and 8)status of recovery and reconstruction. The questions are set in a manner so respondents can answer them by recalling the "then and now" situation from the time of the earthquake occurrences.

3. Attributes of Survey Subjects

Questions on survey-respondents' attributes were based on their gender, age, residence at the time of the earthquake, occupation at the time of the earthquake, human damage to family members, and damage to their houses. In this section, unless specified otherwise, the ratios (%) represent the percentages as "100% for the effective collection number of 3,272." The questionnaire surveys revealed that 45.1% of the respondents (n=1,477) were male and 54.9% (n=1,795) were female; their ages ranged from 18 to 89, with the average age being 53.2 (SD=16.2, 53.7 for males, 52.9 for females (t (3,270)

=1.4, n.s.); by generation, 18–39-year-olds accounted for 23.0% (n=754), 40–59-year-olds for 35.3% (n=1,154), and 60 years or over for 41.7% (n=1,364).

The questionnaire survey on the occupations of the respondents at the time of the earthquake revealed that wage earners (workers) accounted for 40.1% (n=1,312), self-employed for 11.9% (n=388), occupied housewives and househusbands (temporary staff and workers, part-time workers) for 9.4% (n=308), full-time housewives and househusbands for 8.5% (n=277), pensioners for 19.1% (n=624), unemployed and students for 6.3% (n=206), others for 2.1% (n=69), and non-respondents for 2.7% (n=88).

The questionnaire survey on the respondents' residences at the time of the earthquake revealed that Kumamoto City accounted for 23% (n=754), Koshi City for 11.7% (n=384), Kikuchi City for 8.7% (n=284), Kikuyo Town for 7.9% (n=260), Otsu Town for 6.2% (n=204), Masuki Town for 7.4% (n=241), Kashima Town for 1.9% (n=61), Mifune Town for 3.4% (n=111), Kosa Town for 2.2% (n=72), Kami-Masuki County (town name unknown) for 0.03% (n=1), Udo City for 6.8% (n=224), Uki City for 11.9% (n=380), Aso City for 5.1% (n=166), Minami-Aso Village for 2.1% (n=69), and Nishihara Village for 1.6% (n=51).

The questionnaire survey on human damage to the respondents' family members revealed that families with dead members accounted for 0.4% (n=13), families with hospitalized sick and injured members for 2.3% (n=76), families with non-hospitalized sick and injured members for 8.1% (n=264), families with no human damage for 84.4% (n=2,761), and non-respondents for 4.8% (n=158).

The questionnaire survey on damage to the respondents' houses revealed that completely destroyed houses accounted for 4.1% (n=1,340), half-destroyed houses for 13.6% (n=444), partially destroyed houses for 36.5% (n=1,193), houses with no damage for 41% (n=1,340), and non-respondents for 5.0% (n=162).

4. Awareness of Local Active Faults and Preparedness at Earthquake Occurrences

For the question "Before the earthquakes occurred, did you think that the active faults present in your residential area would cause an earthquake," 69.7% of the respondents stated that "they were not aware of any active faults," which indicates that these residents did not know of the presence of active faults in their local areas, 17.3% responded that "probably no earthquakes would occur," 6.9% responded that "an earthquake could occur within the 21st century," 2.9% responded that "an earthquake could occur in 10 years or so," 2.3% responded that "an earthquake could occur within several years," and 0.9% did not respond. About 30% of the respondents were aware of the presence of active faults prior to the earthquake occurrences, but half of them responded that "probably no earthquakes would occur" (**Fig. 2**). By generation

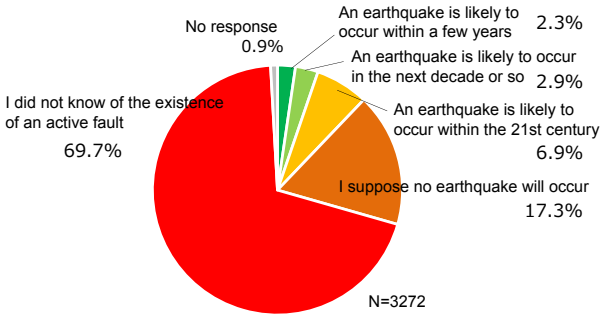

Fig. 2. Before the earthquake occurred, did you ever think that an earthquake could be caused by an active fault in the region?

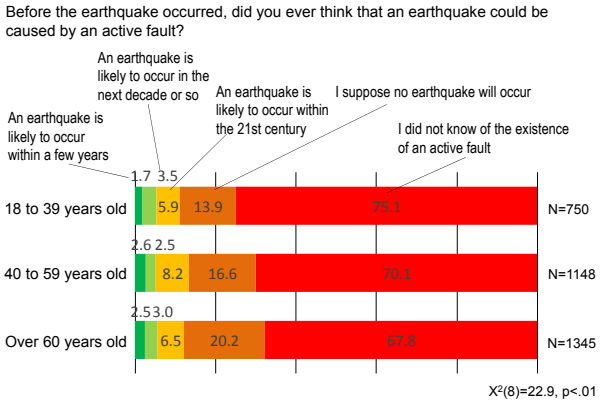

Fig. 3. Possibility of occurrence of earthquake (By age).

(**Fig. 3**), nearly 70% of the respondents stated that they were not aware of the presence of any active faults. Here, the ratio of young generations tends to be larger than that of any other generation ($\chi^2(8) = 22.9$, $p<.01$).

Since the Great East Japan Earthquake, the need to strengthen disaster prevention education for children in elementary, junior high, and high schools has publicly been advocated (MEXT, 2013 and 2014) [10, 11]. Such disaster prevention education should not be limited to schoolchildren but should be extended to adults aged 18 and above (survey subjects of this study) through municipalities' PR, disaster prevention drills, and training programs so that scientific knowledge about local active defaults and related activities can be made available to as many people as possible. The above-mentioned $\chi^2(n)$ represents the stochastic chi square test result. It is a test to examine whether the ratios of values of different events are different from each other and whether it can stochastically denote "the same" if null hypothesis is denied. In this section, we have conducted chi square tests to examine whether the ratios of those who are aware of active faults remain unvaried across generations and found that null hypothesis has been denied at a 1% level, thus, concluding that the ratios of those who are aware of active defaults vary with different generations.

For the question "Circle the items indicating your preparedness for earthquakes at home," 49.9% of the respon-

Fig. 4. Preparation before occurrence of earthquake.

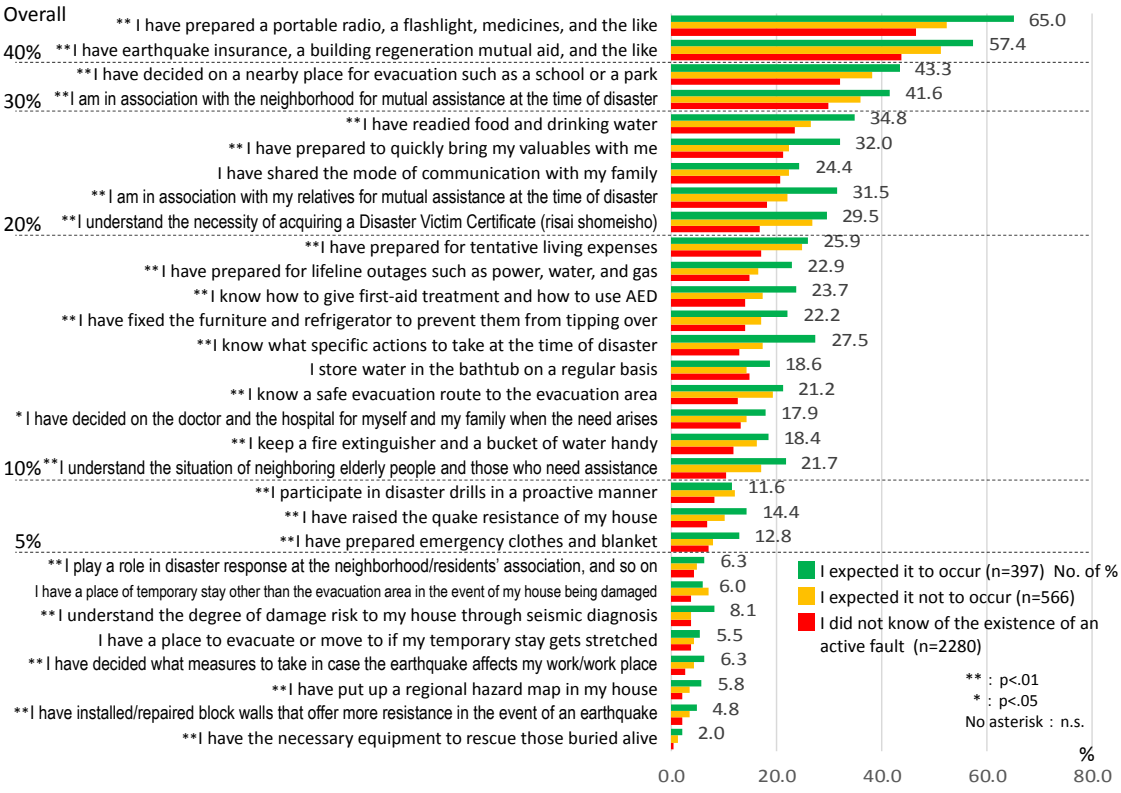

Fig. 5. Preparation before occurrence of earthquake (By potential of earthquake occurrence).

dents stated that they prepared "a portable radio, a flashlight, medicine, and the like," while 46.8% responded that "they had earthquake insurance, building endowment mutual insurance, etc." These two items formulate the largest percentage on the order of 40%, followed by "they have decided where to evacuate - a nearby school or a park"

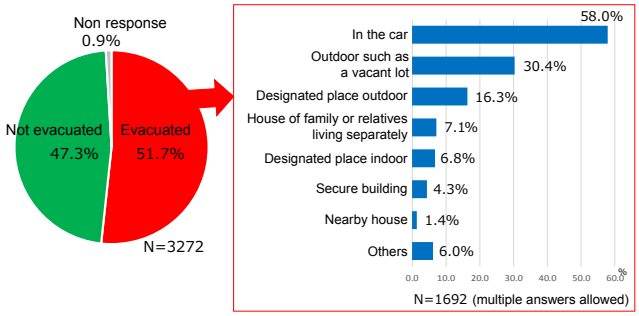

Fig. 6. Evacuation during foreshock (April 14).

Fig. 7. Reason for evacuation during foreshock (April 14).

(34.4%) and "they associate with neighbors, hoping to mutually help in case of a disaster" (32.4%). The latter two items formulate the second largest percentage on the order of 30%. Then, the following five items take the third largest percentages on the order of 20%: "they have prepared food and drinking water" (25.5%), "they have prepared themselves to take out valuables quickly" (22.8%), "they have decided how to contact family members" (21.5%), "they associate with relatives, hoping to help each other in case of a disaster" (20.5%), and "they recognize the necessity for disaster certificates" (20.0%). **Fig. 4** shows the respondents' preparedness in detail.

Figure 5 shows the above-mentioned findings of preparedness analyzed by the probability of earthquake occurrence. The respondents who stated that "they were aware of the local active faults and that an earthquake could occur in 10 years or so" (n=397) hold larger percentages of general preparedness than other respondents, in particular "they know specifically how they should behave in the event of a disaster" (41.6%), "they have prepared a portable radio, a flashlight, medicine, and the like" (65.1%), and "they have prepared themselves to take out valuables quickly" (32.0%). In other words, the respondents have specifically imagined their behaviors in the event of a disaster and they have prepared specific items just in case the disaster arises. The analysis of the findings, by generation, shows that the respondents aged 60 or over are generally better prepared.

5. Victims' Post-Foreshock Behaviors and Anticipation of Aftershock Occurrences

5.1. Post-Foreshock Evacuation, and Sheltering Behaviors and Reasons

We first asked the respondents to tell us what situations they were in when the first big earthquake occurred at 21:26 hours on the night of Thursday, April 14 and then asked them if they evacuated and sought shelter during the said earthquake. Around 51.7% of the respondents evacuated and sought shelter, 47.3% did not, and 0.9% did not respond (graph on the left of **Fig. 6**). We asked those who evacuated and sought shelter exactly where they did so through multiple choice questions, which revealed that 58% of them evacuated and took shelter in cars, 30.4% in

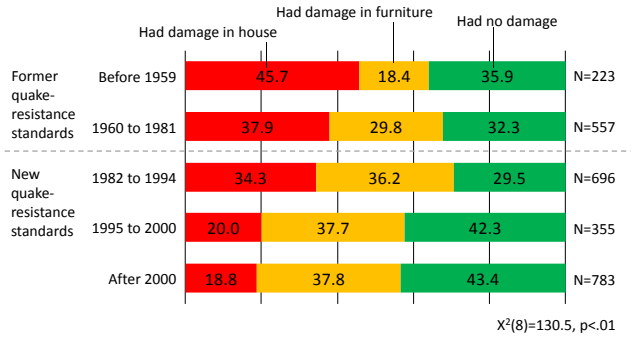

Fig. 8. Year of construction of house and damage by foreshock.

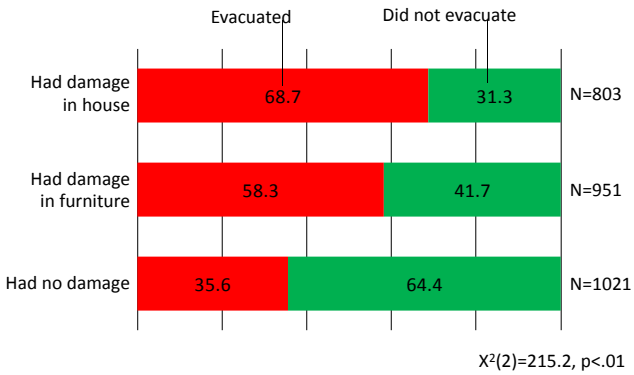

Fig. 9. Damage by foreshock and evacuation during foreshock.

outdoor vacant grounds, and 16.3% in outdoor designated places while a large number of the victims evacuated and took shelter outdoors (graph on the right of **Fig. 6**).

We asked the respondents why they evacuated and took shelter during the foreshocks (**Fig. 7**). Precisely 80.9% responded that they were afraid of aftershocks while 55.7% responded that they felt anxious in their buildings. Thus, the main reasons for their evacuation and sheltering behaviors are their fears of aftershocks and the risk of damage to their buildings. On the other hand, the question concerning why they did not evacuate and take shelter, 51.7% of them responded that their buildings remained undamaged, 38.4% responded that they did not feel it necessary to evacuate and take shelter, 36% responded that their lifelines like power supply, gas, and tap water were available, and 35.1% responded that they thought it safer to stay there. The main reasons for them not evacuating and taking shelter are that their buildings remained undamaged and their lifelines were available to them.

5.2. Relations Between the Age of Residential Buildings, Damage to Houses, and Evacuation/Sheltering Behaviors During Foreshocks

Figure 8 shows the relations between the age of residential buildings at the earthquake occurrence sites and damage to the houses. It was found that older houses sustained more damage as compared to houses built according to the new earthquake resistance standards where the damage was to the furniture rather than to the buildings themselves ($\chi^2(8) = 130.5$, $p < .01$).

Figure 9 shows the relations between damage to the houses and evacuation and sheltering behaviors. Here, people whose buildings and furniture were more heavily damaged evacuated and took shelter ($\chi^2(2) = 215.2$, $p < .01$).

Figure 10 shows the relations between the age of residential buildings and evacuation and sheltering behaviors during the foreshocks. Here, more people living in older houses evacuated and took shelter ($\chi^2(4) = 74.5$, $p < .01$).

The above-mentioned relations between age of residential buildings, damage to houses, and evacuation and sheltering behaviors during foreshocks can be explained by the residents' anxiety about their buildings' safety as the reason for their evacuation and sheltering behaviors.

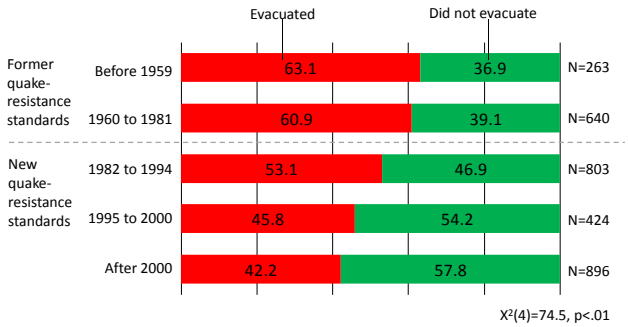

Fig. 10. Year of construction of house and evacuation during foreshock.

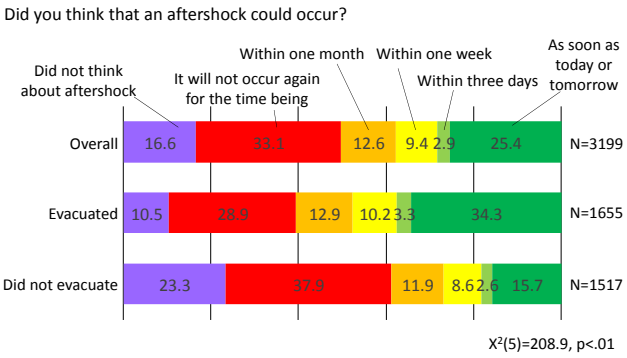

Fig. 11. After-foreshock anticipation of occurrence of aftershock.

5.3. Whether They Anticipated Aftershock Occurrences After Foreshocks

We asked the respondents whether they anticipated another big aftershock following the foreshocks, and asked them to circle the most applicable item. **Fig. 11** shows their responses indicating whether or not they evacuated and took shelter during the foreshocks. About 40% of respondents, who evacuated and took shelter (n=1,655), anticipated a high probability of aftershock occurrences out of which 34.3% responded that "an aftershock could occur in a couple of days" and 3.3% responded that "an aftershock could occur within a few days." About 40% of those who evacuated and took shelter anticipated a low probability of aftershock occurrences, out of whom 28.9% responded that "no more earthquakes would occur

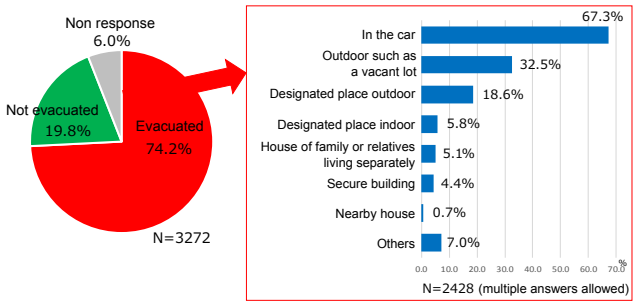

Fig. 12. Evacuation during main shock (April 16).

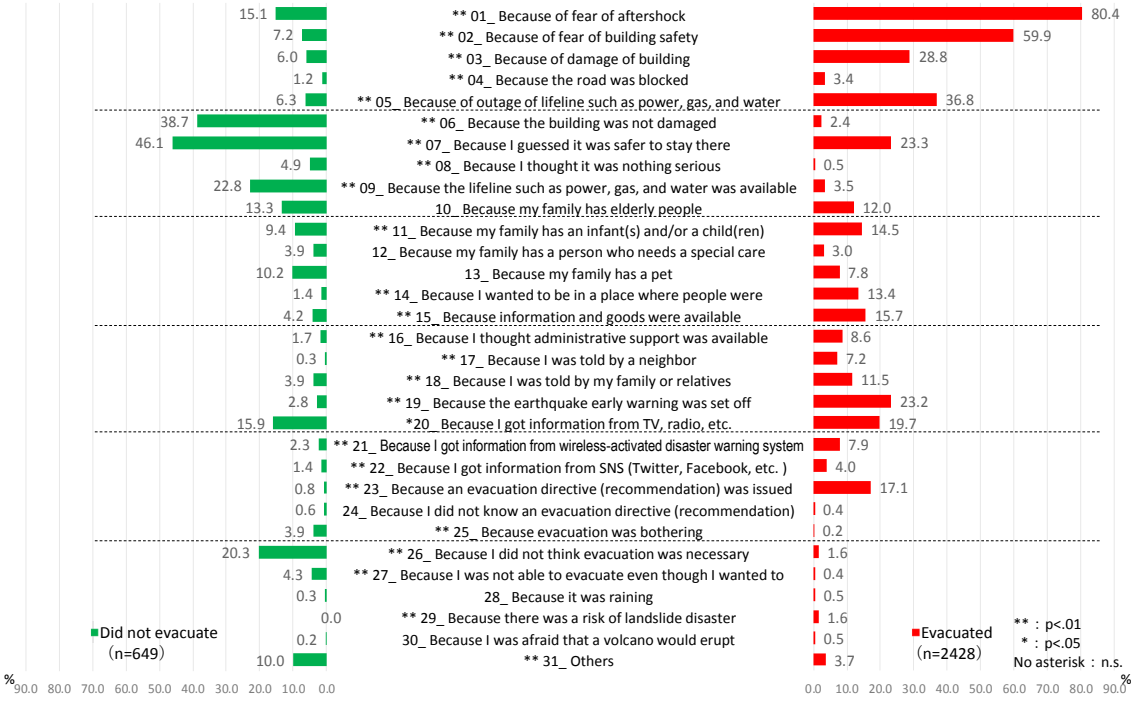

Fig. 13. Reason for evacuation during main shock (April 16).

for a while" and 10.5% responded that "they had no aftershocks in mind."

About 60% of those who did not evacuate and seek shelter (n=1,517) anticipated a low probability of aftershock occurrences out of which 37.9% responded that "no more earthquakes would occur for a while" and 23.3% responded that "they had no aftershocks in mind" ($\chi^2(5) = 208.9$, $p < .01$).

6. Victims' Post-Main Shock Behaviors and Anticipation of Aftershock Occurrences

6.1. Post-Main Shock Evacuation and Sheltering Behaviors and Reasons

Following the questions on the foreshocks, we first asked the respondents to tell us what situations they were in when the main shocks of magnitude 7.3 occurred on Friday midnight, the day following the foreshock occurrence, or at 01:25 hours on the midnight of Saturday, April 16, and then asked them whether they evacuated and took shelter during the main shock occurrence. While 74.2% respondents evacuated and took shelter, 19.8% did not, and 6% did not respond (graph on the left of **Fig. 12**). Coming to the question of where they evacuated and took shelter (multiple choices allowed), 67.3% evacuated and took shelter in cars, 32.5% in outdoor vacant grounds, and 18.6% in outdoor designated places. It can be seen that higher percentages of people evacuated and took shelter outdoors during main shocks than during foreshocks (graph on the right of **Fig. 12**).

Figure 13 shows the respondents' reasons behind their evacuation and shelter during the main shocks. While 80.4% of them responded that they feared aftershocks, 59.9% responded that they were anxious about their buildings, which are the same as the reasons for evacuating and sheltering during the foreshocks. In addition, 36.8% responded that their lifelines such as power supply, gas, and tap water were cut off and 28.8% responded that their buildings were damaged. The actual damage to their buildings and lifelines constitutes some of the reasons behind their evacuation and shelter during the main shocks.

When asked why they did not evacuate and take shelter during the main shocks, 46.1% responded that they thought it safer to stay in their buildings and 38.7% responded that their buildings remained undamaged. Thus, it can be seen that their main reasons for not having evac-

uated and taken shelter are no damage to their houses, no damage to the shelter buildings, and damage to their previous outdoor evacuation destinations.

A comparison of the respondents' reasons for not evacuating and taking shelter during the foreshocks and the main shocks shows the following, "no damage to their buildings": 51.7% at the foreshocks and 38.7% at the main shocks; "they did not think it necessary to evacuate and take shelter": 38.4% at the foreshocks and 20.3% at the main shocks; "their lifelines such as power supply, gas, and tap water were available": 36.0% at the foreshocks and 22.8% at the main shocks. The above-mentioned reasons for not having evacuated and taken shelter are more obvious at the foreshocks than at the main shocks and seem to represent the victims' typical behaviors during inland earthquake occurrences. On the other hand, a comparison of the respondents' reasons for not evacuating and taking shelter during the foreshocks and the main shocks shows the following, "their lifelines such as power supply, gas and tap water stopped": 25.7% at the foreshocks and 36.8% at the main shocks; "their buildings were damaged": 23.1% at the foreshocks and 28.8% at the main shocks. Therefore, it can be seen that more people evacuated and took shelter during the main shocks than during foreshocks. Contrary to most people's expectations, even bigger earthquakes occurred after the second big earthquake (main shocks) that not only damaged extensive areas but significantly changed the victims' state of mind and behaviors.

6.2. Relations Between the Age of Residential Buildings, Damage to Houses, and Evacuation and Sheltering Behaviors During Main Shocks

Figure 14 shows the difference in the damage to houses built in different times. Houses of older origins were more damaged as compared to more than 50% of houses built by the new earthquake resistance standards ($\chi^2(8) = 106.7$, $p < .01$).

Figure 15 shows the relations between damage to houses and evacuation and sheltering behaviors of respondents. About 80% of the respondents whose houses and furniture were damaged, evacuated and sought shelter while about 60% of the respondents whose houses and furniture were not damaged, evacuated and sought shelter ($\chi^2(2) = 79.2$, $p < .01$).

Figure 16 shows the relations between age of residential buildings and evacuation and sheltering behaviors at the time of main shocks. Nearly 80% of the respondents evacuated and took shelter regardless of the age of their houses ($\chi^2(4) = 10.7$, $p < .05$). The comparison with the results of the foreshocks shows that the magnitudes of the main shocks caused damage to the houses regardless of the age of residential buildings, driving the victims to their evacuation and sheltering behaviors.

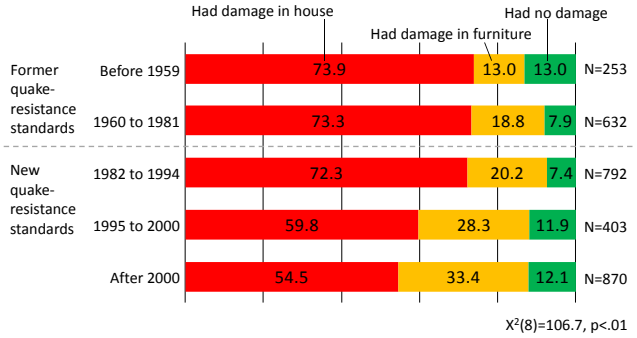

Fig. 14. Year of construction of house and damage by main shock.

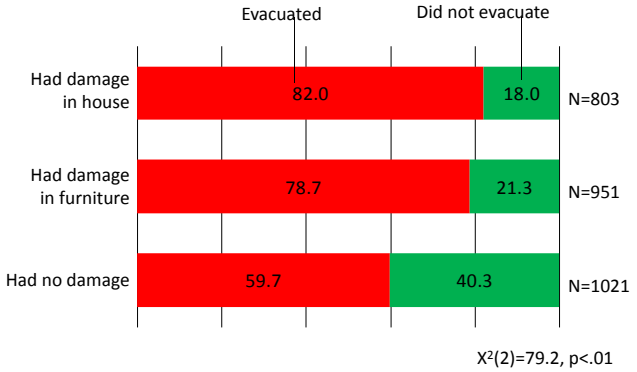

Fig. 15. Damage by foreshock and evacuation during main shock.

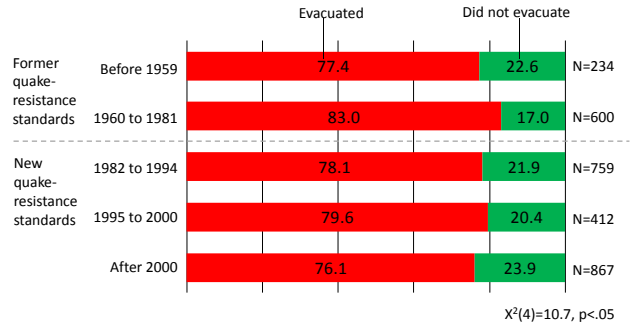

Fig. 16. Year of construction of house and evacuation during main shock.

6.3. Whether They Anticipated Aftershock Occurrences after Main Shocks

We asked the respondents whether they anticipated "another big aftershock might occur" after this earthquake and told them to circle the most applicable item. **Fig. 17** shows that 55.6% of those who evacuated and sought shelter (n=2,392) and 39.0% of those who did not evacuate and seek shelter (n=636) responded that "big aftershocks could occur in a couple of days." On the other hand, a little less than 30% who did not evacuate and seek shelter responded that "no aftershocks would occur for a while" (19.3%) and "they had no aftershocks in mind" (6.6%) ($\chi^2(5) = 70.7$, $p < .01$).

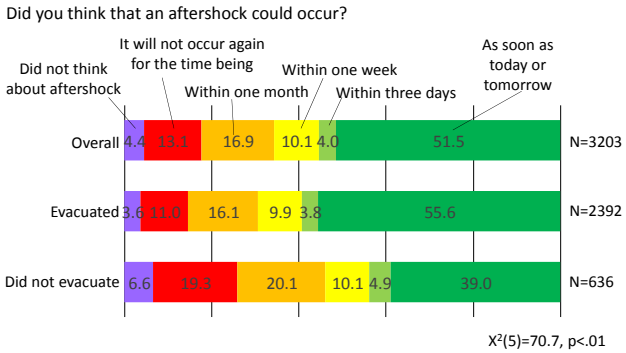

Fig. 17. After-main shock anticipation of occurrence of aftershock.

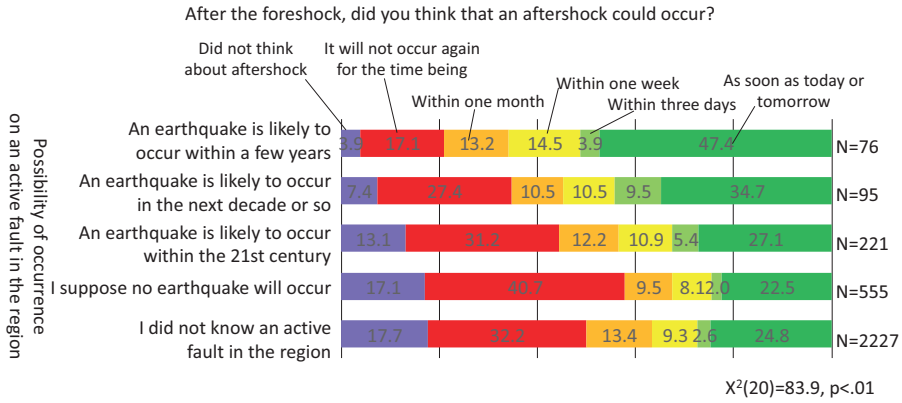

Fig. 18. Recognition of active faults in the region and after-foreshock anticipation of occurrence of aftershock.

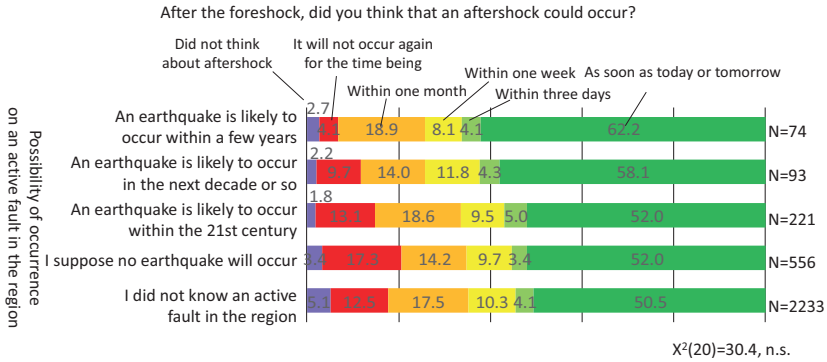

Fig. 19. Recognition of active faults in the region and after-main shock anticipation of occurrence of aftershock.

6.4. How a Difference in Pre-Earthquake Awareness of Local Active Faults Influenced Anticipation of Post-Earthquake Aftershock Occurrences

We have analyzed how the difference in pre-earthquake awareness of local active faults, and the probability of earthquake occurrences due to these active faults, have influenced the victims' anticipation of post-earthquake aftershock occurrences. **Fig. 18** shows the analysis results of their post-foreshock anticipation of aftershocks. Those who felt, prior to the earthquake, that an earthquake could occur in the near future due to the local active faults, anticipated, after the foreshocks that, aftershocks might occur ($\chi^2(20) = 83.9$, $p < .01$). "How the difference in pre-earthquake awareness of local active faults, and the probability of earthquake occurrences due to these active faults, has influenced the victims' anticipation of post-earthquake (foreshocks) occurrences" greater anticipated of post-earthquake aftershock than "how their evacuation and sheltering behavior after the foreshocks influenced their anticipation of aftershock occurrences" (**Fig. 12**). In the event of an earthquake, where damage to humans and houses is minor and the residents cannot decide whether they should evacuate and seek shelter, it seems that their prior knowledge and awareness on similar disasters has some influence on their judgment at the time of earthquake occurrences.

On the other hand, our analysis of the victims' anticipation of aftershocks after the main shocks (**Fig. 19**) shows

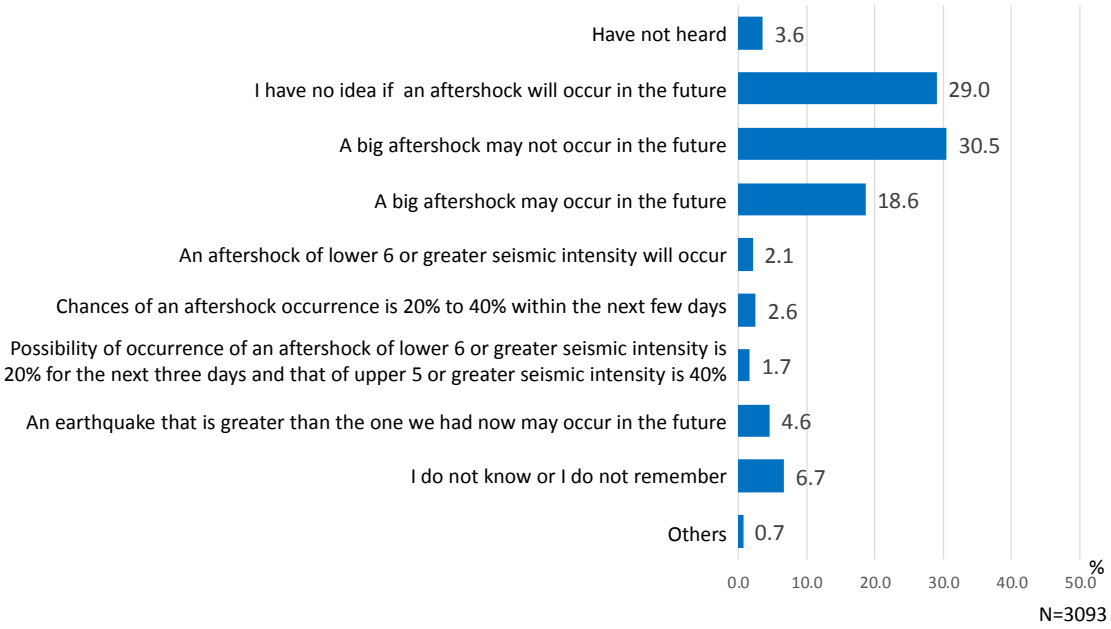

Fig. 20. Aftershock information announcement on the next day of the foreshock.

no statistically significant difference between their pre-earthquake knowledge, and awareness of their local active faults, and their post-main shock anticipation of aftershocks ($\chi^2(20) = 30.4$, n.s.). In the event of an earthquake with great damage to humans and houses, the residents seem to have been urged to evacuate and seek shelter whether or not they have knowledge and awareness about the disasters.

7. Acquisition of Information on Aftershocks and Response Behaviors

7.1. Information on Post-Foreshock Aftershock Activities

The Meteorological Agency issued the sixth report on the 2016 Kumamoto Earthquake at 15:30 hours on April 15, the following day of the foreshock occurrence, in which they announced that "regarding the future aftershock activities, the probability of aftershocks of lower 6 or over on the Japanese scale, occurring in some areas, is 20% for three days from 16:00 hours on April 15 and the probability of aftershock occurrences of upper 5 or over on the Japanese scale is 40%" [12]. Without stipulating the source and contents of the said information, we wrote in the questionnaire, "on the following day (Friday, April 15) of the first earthquake occurrence, information on the aftershocks was released" and asked the respondents what they thought of this information and to circle the most applicable item. The questionnaire intends to establish what information, regarding the aftershocks, the respondents gained and from which source.

Figure 20 shows that 30.5% of the respondents thought that no more big aftershocks would occur in the future. This means that the respondents took the aftershock information, press-released by the Meteorological Agency, contrary to what the latter expected; the aftershock information press-released by the Meteorological Agency was not properly communicated to the residents. While 29% of them thought that aftershocks could occur anytime in the future, 18.6% thought that big aftershocks might occur in the future. They took the aftershock information inexplicitly, without specific knowledge about its magnitude and timing. Only 1.7% responded that they took the aftershock information by the Meteorological Agency's press release as "the probability of aftershock occurrences of lower 6 or over on the Japanese scale is 20% for the following three days and that of aftershock occurrences of upper 5 or over on the Japanese scale is 40%."

Figure 21 shows when the respondents obtained the aftershock information.

A majority of those who responded that "aftershocks could occur anytime in the future," "no more big aftershocks would occur in the future," and "big aftershocks might occur in the future" obtained the aftershock information on the night of April 14 (night after the foreshock occurrence) or on the morning of April 15, which is earlier than the Meteorological Agency's press release on the aftershocks.

Figure 22 shows where the respondents obtained the aftershock information from. Most of them responded that they obtained the information from TVs and radios. This seems to suggest that they obtained information on aftershocks from TV and radio broadcasts, and not from the Meteorological Agency's press release, on the afternoon of the following day. The information broadcast by TVs and radios was not updated and was mistakenly interpreted as "no more big aftershocks would occur in the future."

Figure 23 shows how they behaved on the above-mentioned aftershock information. Large percentages of

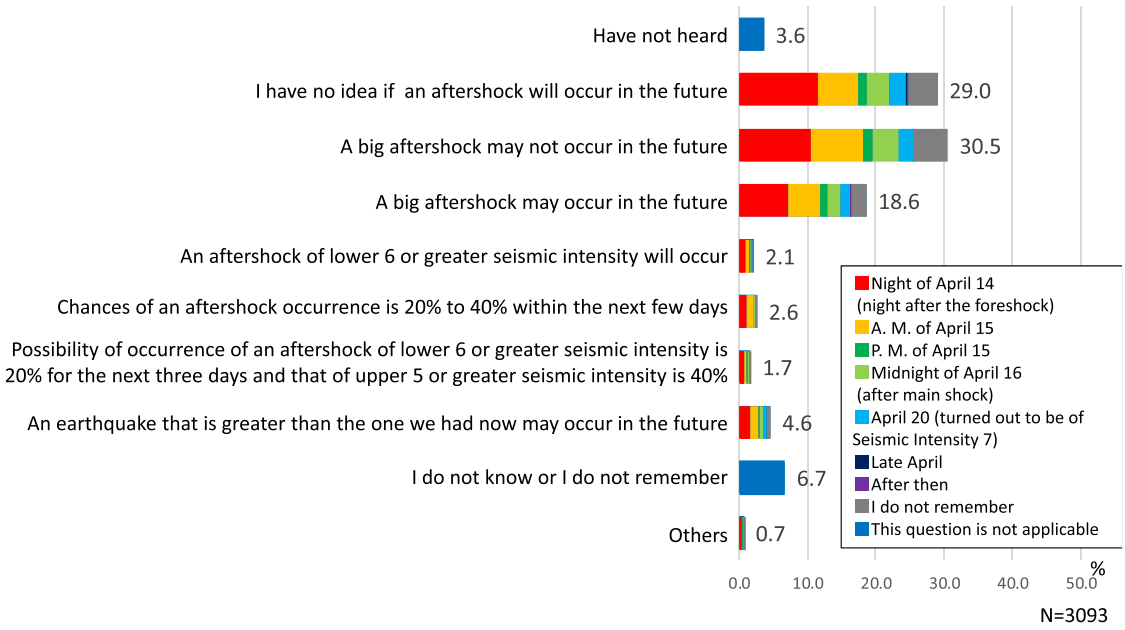

Fig. 21. When did you hear the aftershock information announcement on the day following the foreshock?

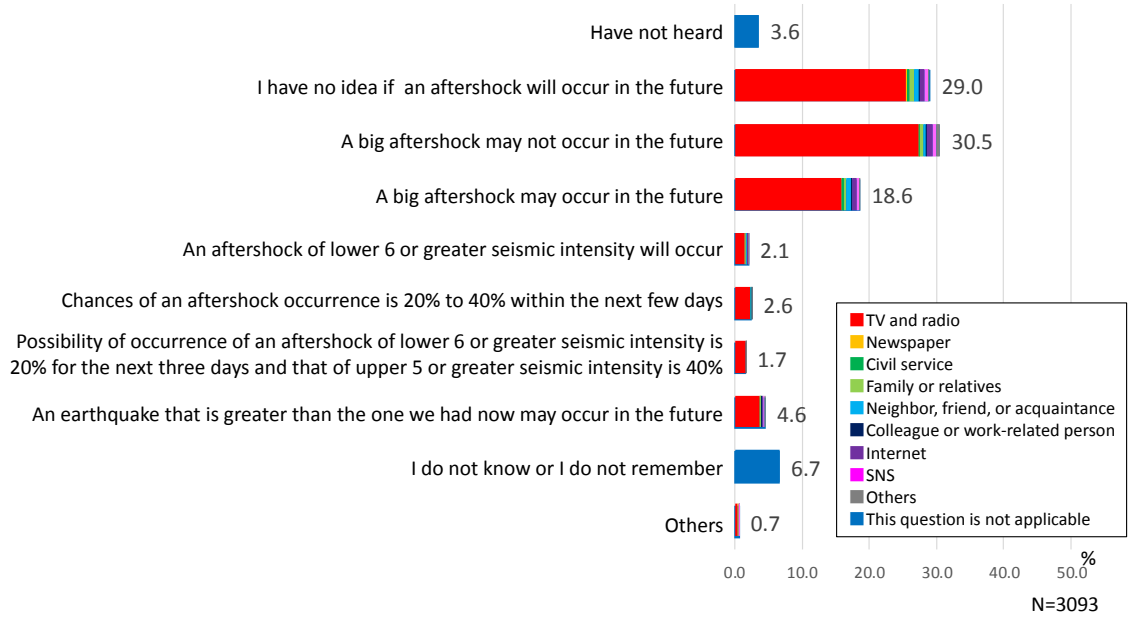

Fig. 22. How did you get the aftershock information on the day following the foreshock?

those who responded that "aftershocks could occur anytime in the future" (n=898) and that "big aftershocks might occur in the future" (n=942) evacuated and took shelter in cars, got out of their houses, or went to shelters. On the other hand, large percentages of those who responded that "no more big aftershocks would occur in the future" (n=575) and that "the probability of aftershocks occurrences of lower 6 or over on the Japanese scale for the following three days is 20% and that of aftershock occurrences of upper 5 or over on the Japanese scale is 40%" (n=53) stayed at home or revealed that the information itself did not lead them to any particular behaviors. This seems to suggest that the Meteorological Agency's press release regarding aftershocks was mostly understood as "no more big aftershocks would occur in the future." As a matter of fact, in the interviews, victims in the affected areas responded that a probability of 20% to them meant "low occurrence, if any"; for example, if the probability of rainfall is 20%, they will not carry umbrellas with them. Therefore, some improvements should be made to the Meteorological Agency's press release so that a probability of 20% could be understood as "a high occurrence probability."

7.2. Information on Post-Main Shock Aftershock Activities

The Meteorological Agency issued statements on April 20, in the week following the main shock occurrence, that

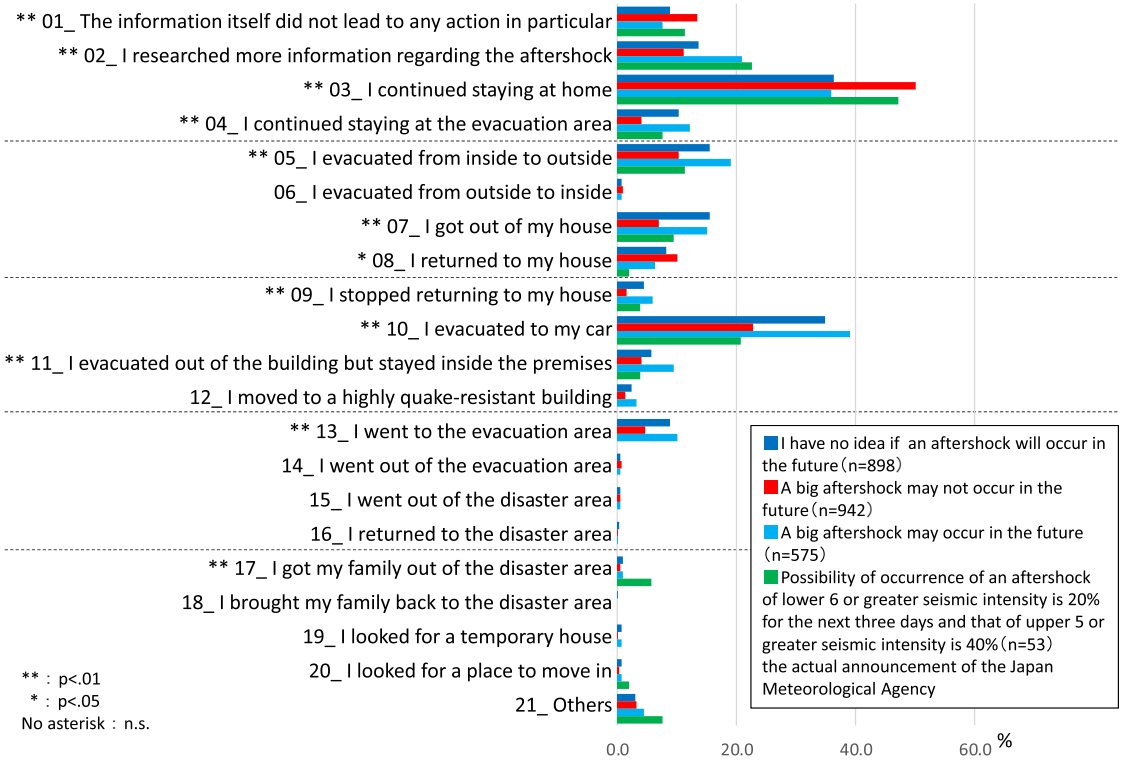

Fig. 23. What kind of action did you take based on the information regarding the aftershock on the day following the foreshock?

as the past experiential rule is not applicable, they would not publish any aftershock occurrence probabilities for the Kumamoto Earthquake, and the Meteorological Agency's Earthquake and Tsunami Observations Division stated, they would review how to communicate such information if necessary (The Sankei Shimbun, 2016) [13]. A newspaper company reported that the Meteorological Agency stopped publishing the aftershock occurrence probabilities for the Kumamoto Earthquake since April 16, when they published that an earthquake of magnitude 7.3 occurred (The Mainichi Shimbun, 2016) [14]. Some of the victims we interviewed in the affected areas stated that "aftershock information stopped being published in the week following the earthquake occurrence" or "there was no aftershock information available."

Without specifying the origin and contents of the information, we wrote in the questionnaire that new information on aftershocks was released on Wednesday, April 20, in the week following the earthquake occurrence and asked the respondents what they thought of the released information on aftershocks and to circle the most applicable item.

Figure 24 shows that 44% responded that "aftershocks could occur anytime in the future" and 23.8% of them responded that "big aftershocks might occur in the future." The majority of responses included "there is no knowing or predicting whether and when aftershocks will occur." A majority of the respondents stated that they obtained the information on April 20, in the week following the earthquake and 80% or more of the respondents stated that they obtained the information from TVs and radios. This suggests that about a week after the earthquake occurrence, scientifically correct information on the aftershocks was widely shared by a large number of people.

Figure 25 shows how the victims behaved in the wake of the above-mentioned information. Those who responded that they took the information as "aftershocks could occur anytime in the future" (n=1,377) or "big aftershocks might occur in the future" (n=747) either stayed at home or evacuated and took shelter in cars. Their behaviors corresponded with the degrees of damage to their houses and there was no statistically significant difference between the above-mentioned two responses and their behaviors. On either of the above-mentioned information they would behave basically the same way.

7.3. Evaluations on Aftershock Information Sources

From the question, "you must have received various kinds of information regarding earthquakes and aftershocks in its aftermath, what do you think of the following items," we have evaluated the following five information sources: Meteorological Agency, Kumamoto Prefecture, National Government, municipalities, and mass media.

Figure 26 shows the respondents' evaluations of the above-mentioned information sources on "whether they communicated the aftershock information intended for residents' safety." Of the total number of respondents who stated that "they thought so very much" and "they kind of thought so," the Meteorological Agency's allotment was 60.5%, Kumamoto Prefecture 53.5%, National Government 46.9%, mass media 44.0%, and municipalities 42.9%.

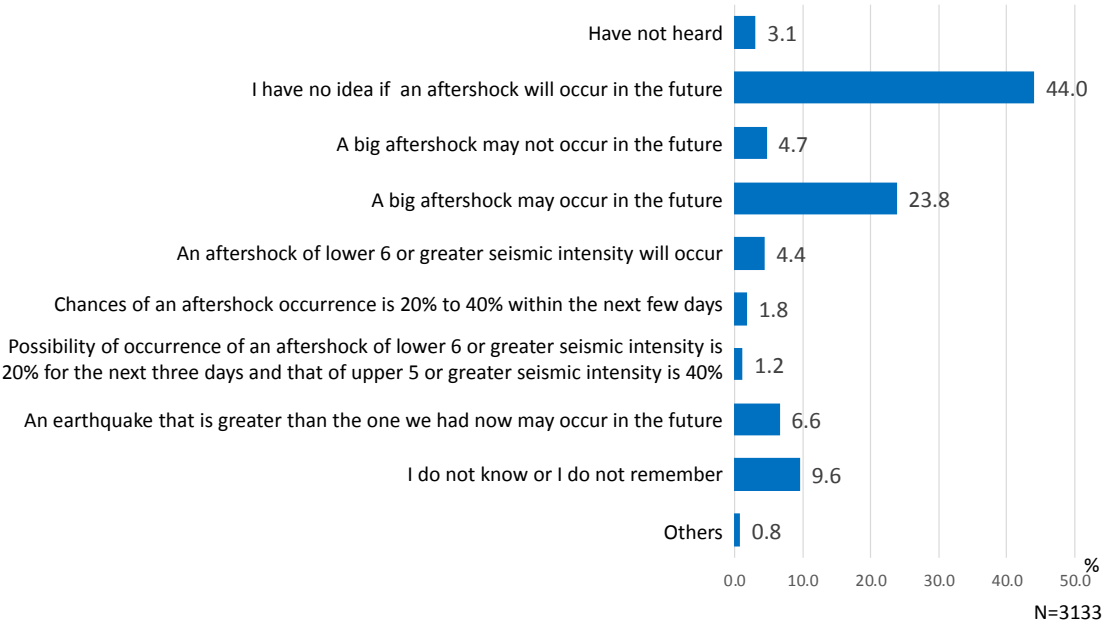

Fig. 24. Information regarding the aftershock in the next week of the earthquake.

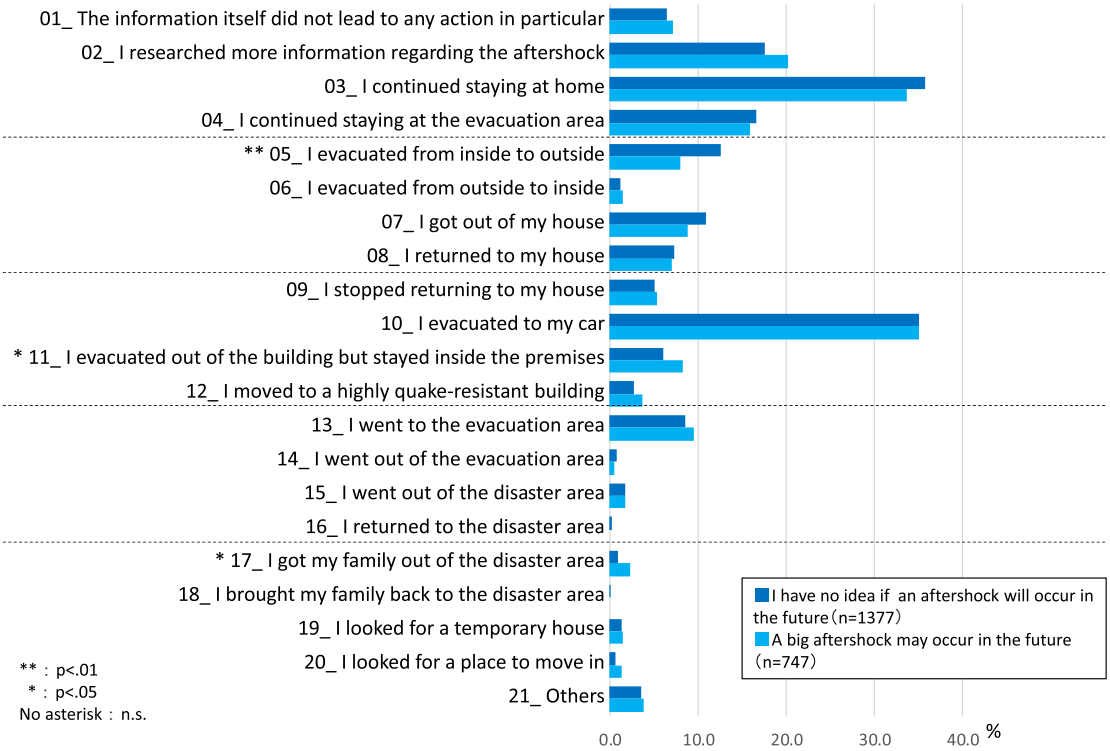

Fig. 25. What kind of action did you take based on the information received regarding the aftershock in the week after the earthquake?

Figure 27 shows the respondents' evaluations of the different information sources based on "whether they found the aftershock information reliable." Of the total number of those who responded that "they thought so very much" and "they kind of thought so," the Meteorological Agency's allotment was 48.1%, that of Kumamoto Prefecture was 42.4%, that of the National Government was 37.5%, that of mass media was 35.0%, and that of municipalities was 33.8%. On both the above-mentioned questions, the Meteorological Agency received a high evaluation, whereas mass media and municipalities received a low evaluation. This suggests that a mechanism needs to be worked out in order to convey the Meteorological Agency's information to municipalities as basic autonomous bodies as quickly and accurately as possible.

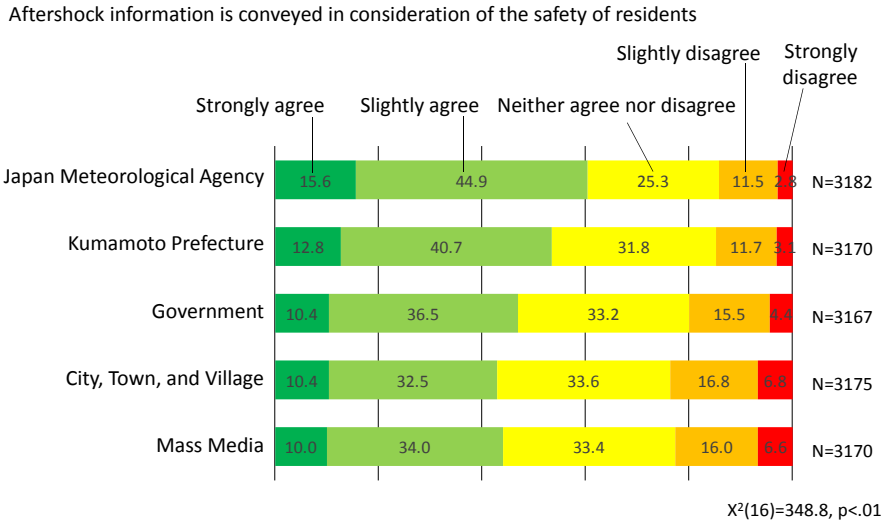

Fig. 26. Evaluation of aftershock information source (1).

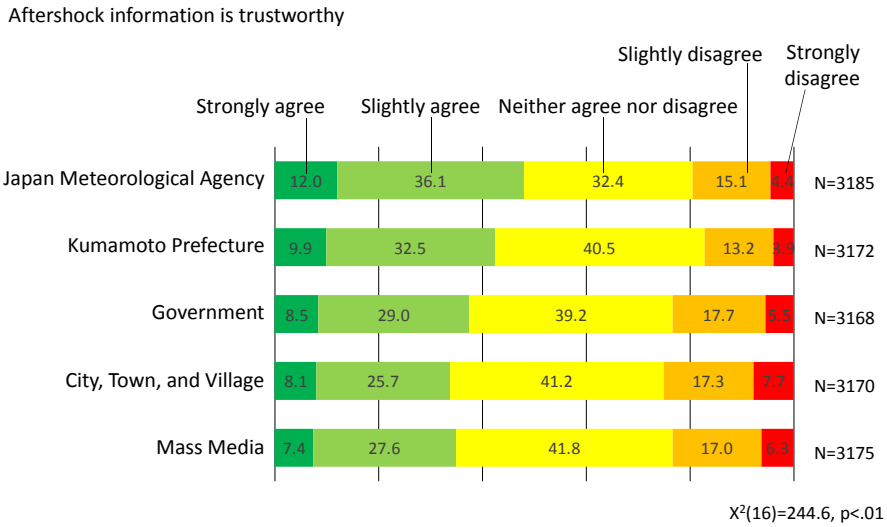

Fig. 27. Evaluation of aftershock information source (2).

8. Movements of Residences and Evacuation Destinations

8.1. Movements of Residences and Evacuation Destinations in Past Inland Earthquake Disasters

Figure 28 shows the residences and evacuation destinations used by the victims from the earthquake-struck day until the surveyed day as revealed in the questionnaires, based on the victims' long-term movements of residences.

There are largely two patterns of movement in the victims' residences and evacuation destinations in the past inland earthquakes that struck modern Japanese society. One pattern is seen in the case of the 1995 Hansin-Awaji (Kobe) Earthquake which had relatively few aftershocks, and the other pattern is seen in the case of the 2004 Mid-Niigata Earthquake which had many aftershocks (Kimura et al., 2010) [6].

Figure 29 shows the movements in the victims' residences and evacuation destinations as found in the random sample questionnaire survey conducted with the victims of the 1995 Hanshin-Awaji (Kobe) Earthquake. The axis of abscissa indicates the logarithmic time course, following the earthquake occurrence, from the left to the right: 10^0 at the left end of the axis of abscissa denotes one hour after the earthquake occurrence, 10 (day of the earthquake occurrence), 10^2 (100 hours: two to four days after the earthquake occurrence), 10^3 (1,000 hours: two months after the earthquake occurrence), 10^4 (10,000 hours: one year after the earthquake occurrence), and 10^5 at the right end of the axis of abscissa (100,000 hours: ten years after the earthquake occurrence). The axis of ordinate indicates the ratios of those who responded that "they were at their respective residences and evacuation destinations at respective points of time on the axis of abscissa." The phases between respective points of time on the axis of abscissa indicate the five processes of disaster as found in the questionnaire surveys of the affected areas in the Hanshin-Awaji (Kobe) Earthquake and subsequent earthquakes (Kimura et al., 2006 and 2010; Kimura, 2012) [15–17] (see additional notes 1 for more details).

Q36. Tell us about the places you stayed at after the earthquake occurred right until the present. During the periods of ① to ⑨, where did you stay the longest for your temporary stay (stay at a place other than the place you call your home)? Please circle the most appropriate answer among 1 to 15 in each period of ① to ⑩.

① After the first earthquake (Thursday, April 14 to Friday, April 15) (Circle the most appropriate one)

1. Did not have a temporary stay (home)
2. Premises of my home
3. House of parents, children, or relatives
4. Friend's house or nearby house
5. Evacuation area (inside the building)
6. Evacuation area (outside the building)
7. Vacant lot
8. In the car
9. Tent
10. Hospital or welfare facility
11. Facility prepared by the company, etc.
12. Hotel or self-rented flat
13. Private rental housing-turned-temporary housing unit
14. Prefabricated temporary housing unit
15. Others (Specify)

To be followed by similar questions regarding the time periods of ② after the main shock (Friday midnight (April 16; Sat.)), ③ the first weekend (April 16; Sat. and April 17; Sun.), ④ the next week of the earthquake (around April 18 to 24: heavy rain warning on April 21; Thu.), ⑤ the second week after the earthquake (late April), ⑥ the first month after the earthquake (mid-May), ⑦ the second month after the earthquake (mid-June), ⑧ the third week after the earthquake (mid-July), ⑨ the fourth week after the earthquake (mid-August), ⑩ the fifth week after the earthquake (mid-September), and ⑪ the present time

Fig. 28. Change in residential areas and evacuation areas over time (Questionnaire examples)

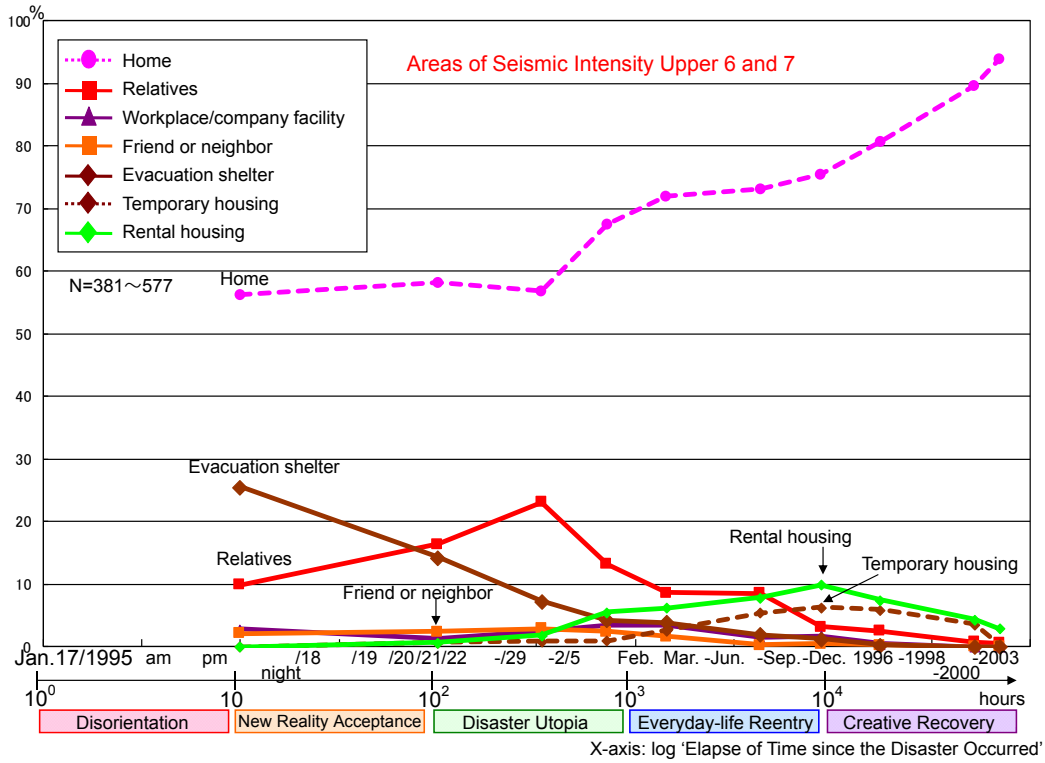

Fig. 29. Changes in the dwelling places of the victims in the 1995 Hanshin-Awaji (Kobe) earthquake (surveyed in 2003).

In the areas stricken by the earthquakes of upper 6 and 7 on the Japanese scale during the Hanshin-Awaji (Kobe) Earthquake, 56.2% of the victims stayed at home on the earthquake-stricken day and 25.5% evacuated and took cover in shelters on the same day. Two to four days after the earthquake disaster, 58.6% stayed at home and 16.4% evacuated and took shelter at their relatives' houses. Two weeks after the earthquake disaster, 23.1% evacuated and remained sheltered at their relatives' houses; the number of the victims who took shelter at their relatives' houses began to decrease afterwards and instead, the ratio of those who lived in rented accommodations, on their own, began to increase. One year after the earthquake disaster, 9.9% of the victims lived in rented accommodations and 6.3% in temporary houses; the ratio of those who lived in houses they rented on their own, was larger than that of

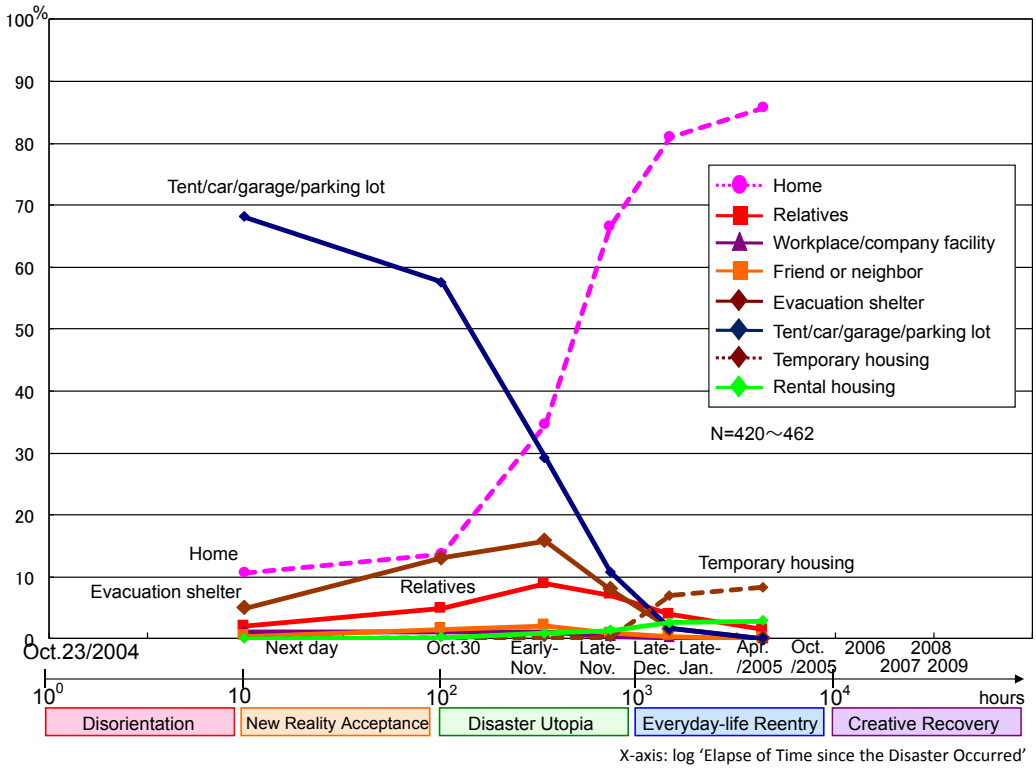

Fig. 30. Changes in the dwelling places of the victims in the 2004 Mid-Niigata Earthquake (surveyed in 2005).

those who lived in temporary houses, at any point of time.

On the other hand, **Fig. 30** shows the movements in the victims' residences and evacuation destinations as found in the random sample questionnaire survey, conducted with the victims of the 2004 Mid-Niigata Earthquake. It shows that 25.3% of the total respondents stayed at home on the earthquake-stricken day and 29.2% stayed at home, even two to four days after the earthquake occurrence. Nearly 70% evacuated and took shelter in places other than their own houses; more specifically, 44.3% of them evacuated and sheltered outdoors in tents, cars, garages, and parking lots on the earthquake-stricken day while the percentage reduced to 35.6%, two to four days after the earthquake occurrence. This is more than the 29.2% that stayed at home. The number of people who evacuated and sheltered outdoors decreased to 19.9%, one week after the earthquake occurrence, and to 2.5%, one month after the earthquake occurrence, which could be explained by the victims' response that a successive series of big aftershocks threatened to damage the buildings so they could not afford to stay indoors in houses or shelters. The ratio of those who evacuated and moved to shelters was 16.3% on the earthquake-stricken day, 22.1% two to four days after the earthquake occurrence, 20.7% a week after the earthquake occurrence, and gradually reduced to 9.3% one month after the earthquake occurrence. mere 5.1% of the respondents evacuated and took shelter in their relatives' houses, which could be explained by the victims' interview that as most of the relatives lived in the rural neighborhood and their houses were also damaged, the relatives' houses could not be an evacuation destination. Around 8.5% of the respondents evacuated and found shelter in temporary houses, three months after the earthquake occurrence, 9.3% did so six months after the earthquake occurrence, and 8.0%, a year after the earthquake occurrence, which indicates that temporary houses served as a major evacuation destination, three months after the earthquake occurrence and afterwards too.

8.2. Movements of Residences and Evacuation Destinations During Kumamoto Earthquake

The questionnaire survey of the Kumamoto Earthquake reveals (**Fig. 31**, **Table 1**) that 57.5% of the total respondents stayed at home after the foreshock occurrence, 28.7% after the main shock occurrence, 32.8% on the first weekend or two to four days after the earthquake occurrence, and 49% in the week following the earthquake occurrence, which increased to 69.5% two weeks after the earthquake occurrence and to over 80%, one month after the earthquake occurrence.

More specifically, 26.2% of them evacuated and sheltered outdoors in cars, tents, and vacant grounds after the foreshock occurrence, 49.2% after the main shock occurrence, and 41.1%, or on the order of 40%, two to four days after the earthquake occurrence, which indicates that more victims evacuated and took shelter outdoors rather than staying at home. The ratio of those who evacuated and took shelter outdoors decreased to 24.4% in the week following the earthquake occurrence, to 10.4% two weeks after the earthquake occurrence, and to 3.3% one month after the earthquake occurrence. On the other hand, 5.9% of them evacuated and moved to shelters after the fore-

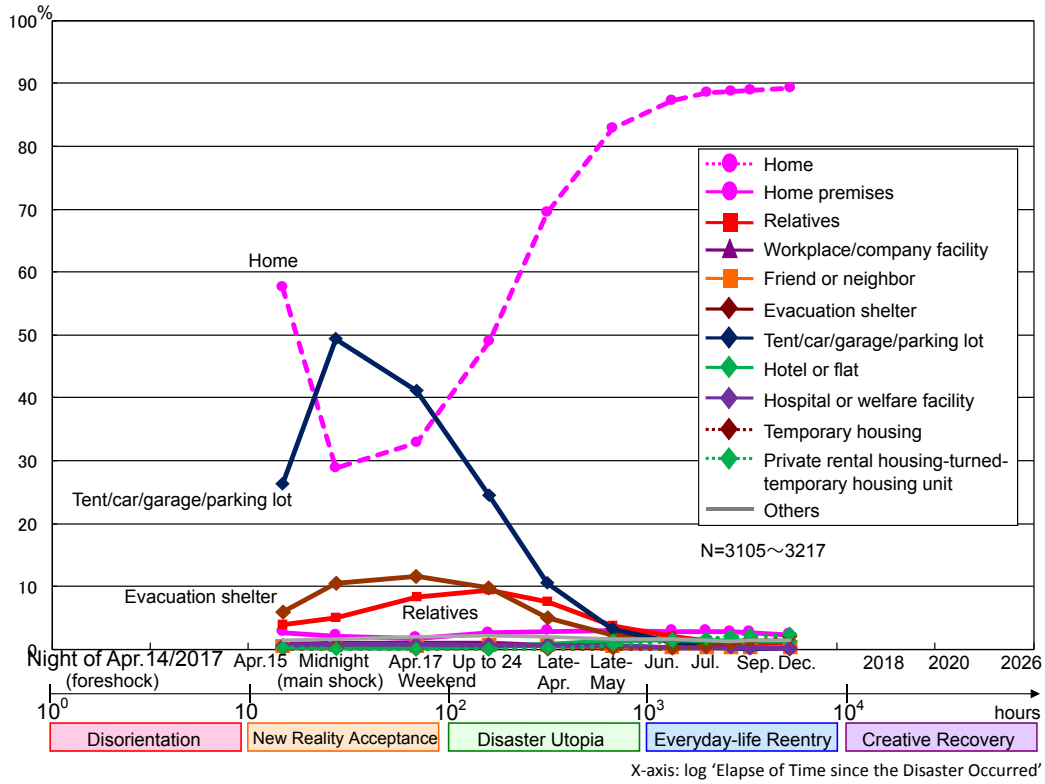

Fig. 31. Changes in the dwelling places of the victims in the 2016 Kumamoto Earthquake.

Table 1. Changes in the dwelling places of the victims in the 2006 Kumamoto Earthquake.

Time elapsed after the disaster	**10 hours**		**10^2 hours**				**10^3 hours**				
Dwelling place	**after foreshock**	after main shock	**First weekend**	Next week	2 weeks	1 month	**2 months**	3 months	4 months	5 months	8 months
Home	**57.5**	28.7	**32.8**	49.0	69.5	82.8	**87.1**	88.5	88.8	88.9	89.3
Home premises	**2.6**	2.1	**1.8**	2.6	2.8	3.1	**2.8**	2.9	2.8	2.7	2.3
Relatives	**3.9**	5.0	**8.4**	9.4	7.6	3.7	**2.1**	1.4	1.2	0.9	0.7
Workplace or company facility	**0.8**	1.0	**0.9**	1.0	0.5	0.3	**0.3**	0.3	0.2	0.2	0.2
Friend or neighbor	**0.5**	0.6	**0.5**	0.7	0.6	0.4	**0.2**	0.2	0.2	0.2	0.2
Evacuation shelter	**5.9**	10.5	**11.5**	9.7	5.0	2.3	**1.4**	0.8	0.7	0.3	0.1
Tent/car/garage/parking lot	**26.2**	49.2	**41.1**	24.4	10.4	3.3	**1.1**	0.5	0.3	0.2	0.1
Hotel or flat	**0.3**	0.3	**0.3**	0.4	0.8	1.3	**1.5**	1.4	1.4	1.3	1.3
Hospital or welfare facility	**0.6**	0.8	**0.8**	0.7	0.6	0.6	**0.2**	0.3	0.3	0.2	0.2
Prefabricated temporary housing	**0.1**	0.1	**0.0**	0.0	0.0	0.1	**0.2**	0.6	0.9	1.4	1.9
Private rental housing-turned-temporary housing unit	**0.2**	0.0	**0.0**	0.0	0.1	0.6	**1.3**	1.7	1.9	2.1	2.4
Others	**1.4**	1.7	**1.9**	2.2	2.0	1.6	**1.6**	1.4	1.3	1.4	1.5
N	**3105**	3117	**3131**	3152	3185	3215	**3213**	3217	3213	3211	3207

shock occurrence, 10.5% after the main shock occurrence, and to a peak 11.5% two to four days after the earthquake occurrence. Around 3.9% of them evacuated and took shelter in their relatives' houses after the foreshock occurrence, 5% after the main shock occurrence, 8.4% two to four days after the earthquake occurrence, and a peak 9.6% in the week following the earthquake occurrence, which decreased to 7.6% two weeks after the earthquake occurrence and to 3.7% one month after the earthquake occurrence.

The questionnaire survey findings show that after the foreshock occurrence, 57.5% of the victims stayed at home, nearly the same as in the case of the Hanshin-Awaji (Kobe) Earthquake, 28.7% of them stayed at home after the main shock occurrence, 32.8% in the first week or about four days after the foreshock occurrence, and 49% in the week following the earthquake occurrence, which indicates that the ratio of those who evacuated and took shelter outdoors in cars, tents, and vacant grounds is larger than those who stayed at home as in the case of the Mid-Niigata Earthquake.

Figure 32 shows the ratios of the victims who stayed at home during the course of the three major inland earthquakes. In the Kumamoto Earthquake, a large number

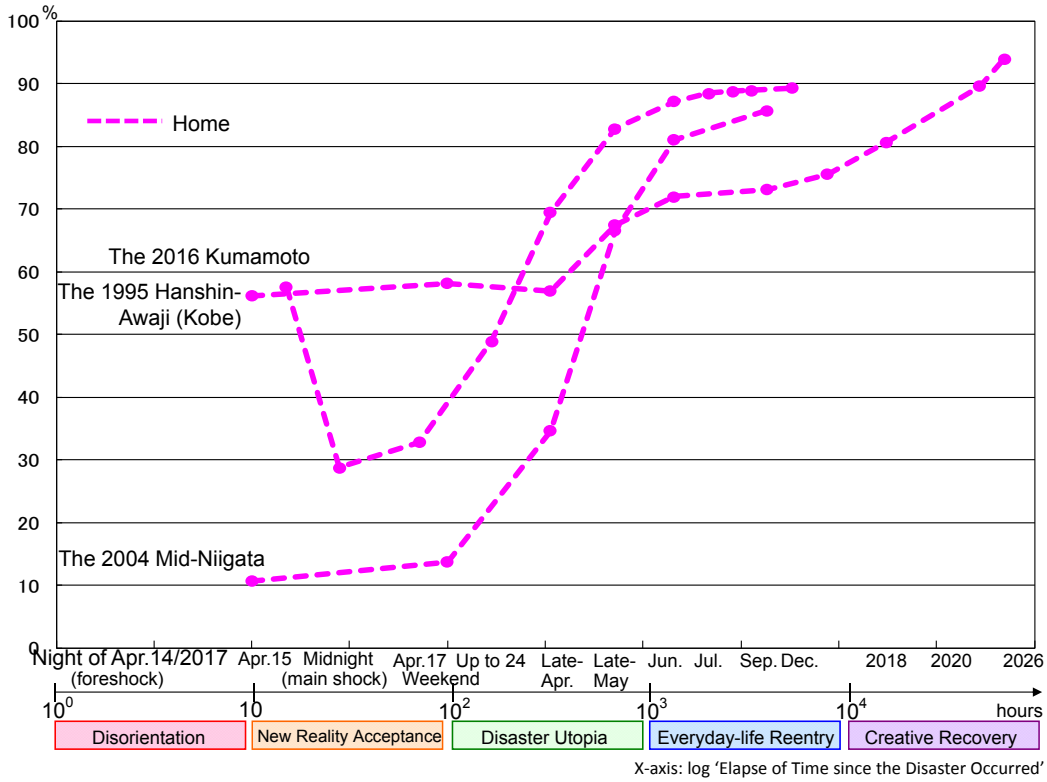

Fig. 32. Changes in the dwelling places of the victims in three inland earthquakes (Home).

of people thought after the foreshocks that "a big earthquake occurs only once" and hence stayed at home during the Hanshin-Awaji (Kobe) Earthquake, but an increasing number of people thought after the main shocks that "aftershocks might occur in the future" and evacuated and took shelter outdoors in the same pattern as seen in the Mid-Niigata Earthquake. The evacuation and sheltering behavior pattern seen during the Kumamoto Earthquake represents a cross between the evacuation and sheltering behaviors of the Hanshin-Awaji (Kobe) Earthquake and the Mid-Niigata Earthquake.

9. Conclusion

In this study, in order to reveal the situations and issues faced by the 2016 Kumamoto Earthquake victims eight months later, we conducted large-scale random sample questionnaire surveys from November to December 2016. In the Kumamoto Earthquake, two successive occurrences of earthquakes of magnitude 7 on the Japanese scale, foreshocks and main shocks, and their aftershocks seem to have significantly influenced the victims' response behaviors, and the recovery and reconstruction of the affected areas. In this study, therefore, we have investigated how the victims behaved during the foreshocks and main shocks, whether the victims' pre-earthquake knowledge and awareness influenced their post-earthquake behaviors, whether aftershock information was properly communicated to the victims, and how the aftershock information influenced the victims' evacuation and sheltering behaviors.

Our questionnaire survey on whether the victims' pre-earthquake knowledge and awareness influenced their post-earthquake behaviors reveals that no more than 30% of the victims knew of the presence of active faults before the earthquake occurrence, and a half of them thought that no earthquake would occur; nearly 70% of people in every generation responded that they did not know of the presence of local active faults. This reminds us of the necessity of disaster prevention education for children as well as for spreading scientific knowledge on local active faults through autonomous bodies' press release or disaster prevention drills and trainings. The questionnaire survey also reveals that such knowledge and awareness on disasters leads people to their pre-earthquake provisioning behaviors as demonstrated by those who were aware of their local active faults and thought an earthquake could occur in about ten years and who actually imaged how they should behave in the event of a disaster and provided for specific goods and provisions.

Our questionnaire survey on how the victims behaved at the foreshocks and main shocks reveals that 51.7% of them evacuated and took shelter after the foreshock occurrence and 47.3% did not. Those who feared the aftershocks or risk of damage to their buildings evacuated and found shelter, and those whose buildings were not damaged or whose lifelines remained intact did not evacuate and seek shelter. About 74.2% evacuated and sought shelter after the main shock occurrence and 19.8% did not. Those who evacuated and took shelter after the main shock occurrence cited actual damage to their build-

ings and unavailable lifelines, in addition to fears of aftershocks, as the reasons for their evacuation and sheltering behaviors.

Our questionnaire survey on whether the victims' pre-earthquake knowledge and awareness influenced their post-earthquake behaviors reveals that in the event of an earthquake, like the Kumamoto Earthquake's foreshocks, where humans and buildings were relatively undamaged, respondents could not decide whether they should evacuate and take shelter; those having pre-earthquake knowledge and awareness better anticipated aftershocks. On the other hand, in the event of an earthquake like the Kumamoto Earthquake's main shocks where humans and buildings were extensively damaged, people were urged to evacuate and seek shelter whether they had pre-earthquake knowledge and awareness or not.

Our questionnaire survey on whether the aftershock information was properly communicated to the victims reveals that they obtained aftershock information, broadcast by TVs and radios, right after the foreshock occurrence, and that they did not follow the Meteorological Agency's press release regarding the aftershocks on the afternoon of the following day for an update. To make matters worse, they followed the information broadcast by TVs and radios that said "no more big aftershocks would occur in the future," which was completely different from what the Meteorological Agency meant by the press release.

Our questionnaire survey on how much the aftershock information influenced the victims' evacuation and sheltering behaviors reveals that the Meteorological Agency's press release stating "the probability of aftershocks of lower 6 or over on the Japanese scale is 20% for the following three days and the probability of aftershocks of upper 5 or over on the Japanese scale is 40%" influenced the behaviors of the victims who took it to mean that "no big aftershocks would occur in the future" as compared to the victims who took it to mean that "aftershocks could occur anytime in the future" or "big aftershocks might occur in the future."

Our questionnaire survey on the status of recovery and reconstruction from the earthquakes reveals 57.5% of the total respondents stayed at home after the foreshock occurrence, which is not so different from the case of the Hanshin-Awaji (Kobe) Earthquake which witnessed relatively few aftershock activities, 28.7% stayed at home after the main shock occurrence, 32.8% stayed back on the first weekend or about four days after the foreshock occurrence, and 49% in the week following the earthquake occurrence, which indicates that the ratio of the victims who evacuated and sheltered outdoors in cars, tents, and vacant grounds were larger than that of the victims who stayed at home as seen in the case of the Mid-Niigata Earthquake which witnessed many aftershock activities. After the foreshock occurrence, a large number of people thought "a big earthquake should occur only once" and stayed at home in the same pattern as the Hanshin-Awaji (Kobe) Earthquake, but after the main shock occurrence, people who thought "aftershocks could occur in the future" increased in number and evacuated and took shelter outdoors in the same pattern as the Mid-Niigata Earthquake. Therefore, the pattern of the victims' evacuation and sheltering behaviors in the Kumamoto Earthquake may be regarded as a cross between the Hanshin-Awaji (Kobe) Earthquake and the Mid-Niigata Earthquake.

The recovery and reconstruction, following the Kumamoto Earthquake, is still underway. While our questionnaire survey focused on the victims' evacuation and sheltering behaviors after the foreshock and main shock occurrences, their common long-term goal should be life recovery, but the routes to their individual life recoveries will be widely diverged, due to their personal circumstances, once they accomplish their lifeline recovery and community planning, and obtain their new homes. In the future, government staff in charge of disaster response should prepare themselves to provide support that meets the needs of each victim so that no victim is left vulnerable.

Note:
The behavioral patterns of victims appear to change in five time phases divided by four time criteria: 10 hours (the day of the disaster), 102 (100) hours (2-4 days after the disaster), and 103 (1,000) hours (two months after the disaster), and 104 (10,000) hours (one year after the disaster). In other words, victims reconstruct their lives after passing through five stages following an earthquake. These five stages are defined as follows:

I. Disorientation phase – a period in which victims suffer from the disaster impact so severely that they have difficulty in objectively understanding what is going on and suffer from narrow vision.

II. New reality acceptance phase – a period in which victims accept damage rationally, as the extent of damage become clear, and undertake to adapt themselves to the "new" society based on a "new" order.

III. Disaster utopia phase – a period in which lives are formed based on social values different from those of ordinary times because of the physical destruction of infrastructures and the paralysis of social functions thus far such as lifeline service (electricity, gas, water supply and sewerage systems services).

IV. Everyday-life re-entry phase – a period in which victims attempt to reconstruct their lives and the special local society in affected area is due to the restoration of social flow systems such as lifeline services.

V. Creative recovery phase – a period in which infrastructure services such as water, sewage, and city-gas systems are recovered and victims no longer see themselves as victims but pursue sustainable advances toward a new social environment.

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