Paper:

# The Influences of Residents' Evacuation Patterns in the 2016 Kumamoto Earthquake on Public Risk Perceptions and Trust Toward Authorities

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**The 2016 Kumamoto earthquake consisted of a magnitude 6.2 foreshock that occurred on the 14th of April, and a magnitude 7.3 main shock that occurred on the 16th of April. The main shock occurring over the magnitude 6.2 foreshock was not anticipated because the foreshock was originally considered to be the main shock. After the earthquakes occurred, the Japan Meteorological Agency (JMA) discontinued its policy of announcing the probability of aftershock occurrences. The experience of the Kumamoto earthquake and the policy change concerning risk communication may affect the public risk perception of earthquakes, as well as the public trust toward authorities. In this study, we examined the reasons residents made the decision to evacuation both the foreshock and the main shock. Moreover, we investigated how residents perceived subsequent earthquake risk and they evaluate similarity and trust toward the authorities (the JMA, government, mass media, prefecture, and municipality). This study analyzed data from a mail survey implemented by the MEXT of Japan in the areas of the Kumamoto prefecture that were damaged by the earthquake. As a result, there were differences in the reasons for evacuation decisions between the foreshock and the main shock. Although residents decided to evacuate based on a fear of disaster in the foreshock, they decided to evacuate the main shock based on neighborhood communication. Moreover, the residents' evacuation patterns influenced the earthquake risk perception. As well, the evacuation pattern influenced similarity toward the authorities and then reduced trusts toward the authorities. This study indicates that residents amplified the evaluations of the authorities after the earthquake. The influences of similarities toward the authorities became salient as a determinant of trust. This study reveals features of residents' risk reactions to the earthquake, and discusses the importance of the similarity of the authorities for disaster risk communication.**

**Keywords:** Kumamoto earthquake, risk communication, risk perception, similarity, trust

## 1. Introduction

A shock of Mj6.5 occurred on April 14, 2016, with the epicenter being located in the Kumamoto District of the Kumamoto Prefecture. The foreshock of this earthquake recorded an intensity of 7 in Mashiki Town of Kumamoto Prefecture. In addition, on April 16, a shock of Mj7.3 occurred with the epicenter being located in the Kumamoto District of the Kumamoto Prefecture. This main shock recorded an intensity of 7 in Nishikara Village and Mashiki Town.

The Kumamoto earthquake was a disaster in which residents experienced successive large-scale foreshock and main shock over a short period of time. Except for seismology experts, the public did not anticipate the main shock on April 16, and probably considered the Kumamoto earthquake as a kind of black swan [1]. After the Great East Japan Earthquake, the limitations of existing disaster management against unexpected circumstances has been discussed [2]. Risk management that can prepare for unprecedented disaster is an urgent issue.

In fact, a new evacuation pattern that differs from previous ones used in past earthquake disasters was formed by residents affected by the Kumamoto earthquake. The pattern reflects the circumstance in which the main shock and foreshock successively occurred over a short period of time. The affected residents can be categorized into those who took evacuation actions after the foreshock and main shock, those who took evacuation actions after the foreshock and continued them after the main shock, those who first took evacuation actions after the main shock, and those who did not take evacuation actions after either the foreshock or the main shock. Therefore, this study aims at investigating the following: 1) the difference of evacuation reasons of residents after the foreshock and main shock; and 2) the effects of evacuation action patterns categorized in terms of evacuation actions after the foreshock and main shock on risk perception for future earthquakes, as well as on the trust placed on risk communication entities.

Few studies have examined the reasons behind decision-making with regard to evacuation actions dur-

ing earthquake disasters [3, 4]. Regarding the case of the Mid-Niigata Prefecture Earthquake in 2004, the main reported reasons for evacuation were anxiety, the fear of building collapse, and the fear of aftershocks [3]. The reasons for evacuation actions, especially after the generally unexpected main shock, can be important findings when considering disaster risk management in addition to the question of whether an evacuation action was taken for the same reason after the foreshock and main shock. Moreover, social networking services (SNS) have been attracting attention as forms of communication media during disasters [5]. Therefore, the effects of SNS on evacuation action decisions during the Kumamoto earthquake are also examined in the study.

After the Kumamoto earthquake, in which a greater main shock occurred after a foreshock that was initially acknowledged as the main shock, the Japan Meteorological Agency (JMA) altered its announcement policy for aftershock probability information because past empirical rules were deemed useless [6, 7]. Some studies indicated that the public does not always seriously regard disaster probabilistic information [8]. However, the effect of the Kumamoto earthquake's change in risk communication policy on reactions against disaster risks needed to be investigated. The framework of social amplification discusses that risk perception is based on hazards interact with psychological and social, institutional, and cultural processes [9, 10]. Public risk reactions to the Fukushima nuclear accidents are discussed to be affected by the informational environments of communication [11].

Risk is originally a constructive concept and what is regarded as a risk is dependent on social values [12]. In the domain of risk perception research, empirical studies have examined the psychological process of cognitions of risk. The main findings indicate that risk perception is based on subjective aspects such as "dread" and "unknown" [13]. In addition, risk perception is considered to be based on two thinking system. System 1 involves experiential decision-making that is based on affective experience and intuition, while system 2 involves analytic decision-making that is based on knowledge and rationality [14]. Therefore, in order to clarify the reaction of the residents against the risks of the Kumamoto earthquake, we examined the effects of the experience of evacuation action decision-making after the foreshock and main shock on the aspects of risk perception. In particular, characteristics of the reactions against disaster risk are clarified from the differences in aspects of experiential judgement (system 1) and analytic judgement (system 2).

Furthermore, trust is an important factor in the risk communication field. It is impossible for the public to evaluate disaster risks. Therefore, judgment on risks must be entrusted to trustworthy experts and specialized institutions. Previous studies discuss that public trust is based on similarity value with experts, in addition to the competence (i.e. expertise to scientifically judge) and honesty (i.e. communicate the judgement in a fair manner) [14, 15]. If experts communicate risks precisely and honestly, they will not be trusted when they are not carefully for the public. Nakayachi et al. [16] indicated that the effect of similarity on trust has been salient for organizations which lost trustworthiness after the Great East Japan Earthquake. On the other hand, the public's trust of organizations related to risk communication is relatively stable even when they experienced the Great East Japan Earthquake [17, 18]. Thus, we examined how the experience of evacuation action decision-making during the Kumamoto earthquake affected the acknowledgement of similarity and trust on organizations related to risk communication. Especially, the effect via similarity is clarified as an affecting process for trust after the Kumamoto earthquake experience.

## 2. Method

### 2.1. Survey Data

This study used research data from the "Questionnaire survey and analysis on effect of aftershock information and evacuation actions during the 2016 Kumamoto earthquake," which was performed by the Ministry of Education, Culture, Sports, Science and Technology (MEXT) from November 28 to December 19, 2016 [19]. Respondents were those who lived in 14 municipalities where earthquake damage was severe. All 14 municipalities met one or more of the following conditions: 1) They experienced a seismic intensity of 6 upper or more of the main shock, 2) 10% or more of all houses were totally collapsed (500 buildings or more in the districts of Kumamoto City, an ordinance designated city), 3) 20% or more of all houses were partly collapsed, or 4) 15% or more of all residents were included in the number of evacuees.

The municipalities that met these conditions were Higashi-ku and Minami-ku of Kumamoto City, Koshi City, Kikuchi City, Kikuchi-gun (Kikuyo Town and Otsu Town), Kami-Mashiki-gun (Mashiki Town, Kashima Town, Mifune town, and Kosa Town), Uto City, Uki City, Aso City, and Aso-gun (Minami-Aso Town and Nishihara Village). The survey was conducted by mail.

### 2.2. Respondents

Male and female adults over 18 were systematically sampled from the poll book or the Basic Resident Register. The sample number was 7000, while the number of valid responses was 3772 (a valid response rate of 46.7%). Male and female valid respondents accounted for 45% and 55%, respectively. The average respondent age was 53.24 ($SD = 16.20$).

### 2.3. Measurements

Refer to the MEXT (2017) [19] for individual attributes, human suffering such as injuries and illness due to the disaster, and damage of property involving houses and furniture. Items of risk perception against the earthquake and similarity and trust for organizations related to

**Table 1.** Results of the logistic regression analysis of reasons for evacuation decisions in the foreshock.

| | B | Wald | odds rate | LL95%CI | UL95%CI |
|---|---|---|---|---|---|
| Anxiety for building safety | 3.73 | 83.38 ** | 41.53 | 18.66 | 92.41 |
| Fear for aftershocks | 3.67 | 333.22 ** | 39.27 | 26.48 | 58.25 |
| Evacuation instruction (recommendation) received | 2.82 | 30.68 ** | 16.69 | 6.17 | 45.19 |
| Rainfall | 2.69 | 2.75 † | 14.68 | .62 | 350.67 |
| Just wanted to meet people | 2.34 | 14.65 ** | 10.38 | 3.13 | 34.42 |
| Advice from neighbors | 2.33 | 8.14 ** | 10.29 | 2.07 | 51.00 |
| Advice from family members or relatives | 2.05 | 29.42 ** | 7.77 | 3.70 | 16.31 |
| Damage of building | 2.01 | 16.83 ** | 7.45 | 2.86 | 19.46 |
| Public services as power, gas, and water interrupted | 1.05 | 7.29 ** | 2.86 | 1.33 | 6.14 |
| Age | .01 | 4.82 * | 1.01 | 1.00 | 1.02 |
| Failure to evacuate against the will | -1.90 | 9.67 ** | .15 | .05 | .50 |
| Information from SNS (Twitter, Facebook, and so on) | -1.60 | 4.05 * | .20 | .04 | .96 |
| No damage of building | -1.39 | 38.59 ** | .25 | .16 | .39 |
| No need to evacuate | -1.16 | 21.29 ** | .31 | .19 | .51 |
| Public services such as power, gas, and water | -.90 | 12.47 ** | .41 | .25 | .67 |
| The earthquake was felt insignificant | -.88 | 8.39 ** | .42 | .23 | .75 |
| Intercept | -1.94 | 44.57 ** | .14 | | |
| log likelihood | 1134.9 | | | | |
| Cox and Shell $R^2$ | .64 | | | | |
| Nagelkerke $R^2$ | .86 | | | | |

$\dagger p < .10, * p < .05, ** p < .01$

risk communication are rated on a five-point Likert scale ranging from 1 (completely disagree) to 5 (completely agree).

#### 2.3.1. Reasons for Evacuation Decision in the Foreshock and Main Shock

Respondents were asked to answer a question regarding whether they evacuated after the shocks, and to then select reason(s) (multiple answers allowed) whey they evacuated (or did not evacuated) from a list of 31 items (see Appendix).

#### 2.3.2. Earthquake Risk Perception

The following three dimensions of items resulted of factor analysis consist of: 1) Severity ($\alpha = .91$, serious damage will occur if an earthquake hits this region again, damage will occur in the entire region if an earthquake hits this region again), 2) Knowledge ($\alpha = .56$, the scientific understanding of earthquakes is advancing, damage can be minimized if an earthquake hits this region again, the damage that will be caused by an earthquake is well-known) 3) Uncertainty ($\alpha = .64$, an earthquake can occur at any time, an earthquake causes various forms of damage and the effects are seen over a long period of time).

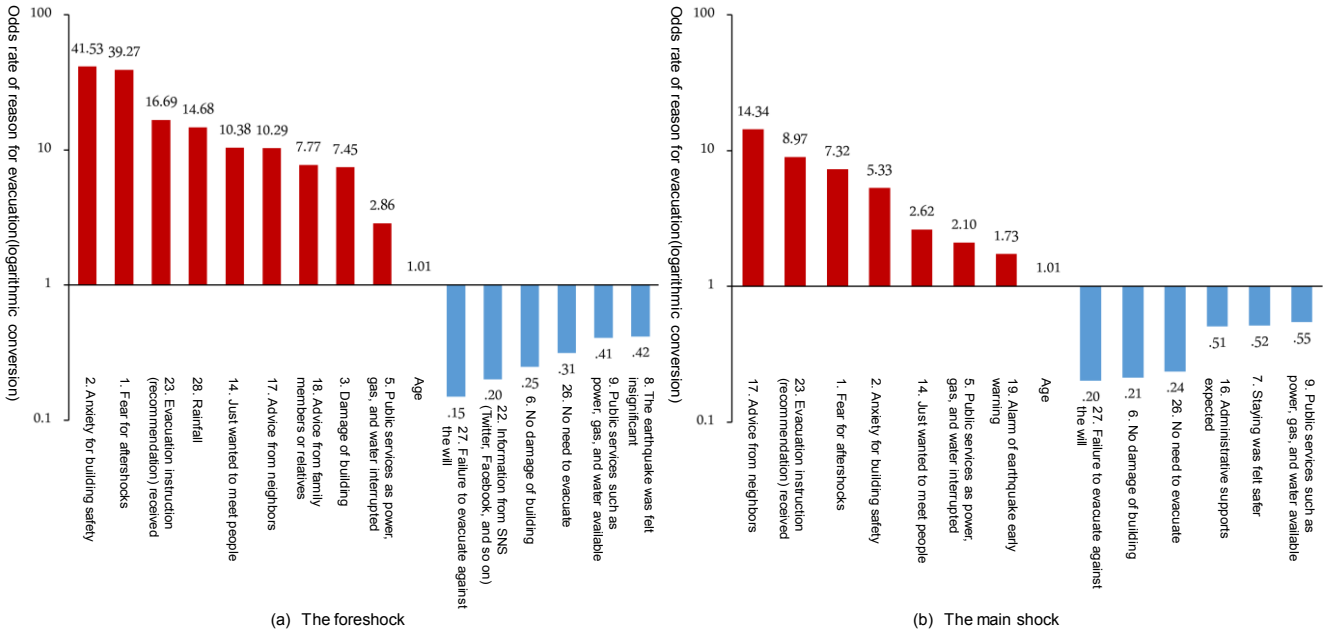
#### 2.3.3. Similarity and Trust Toward Authorities

The same question items were used for the JMA, government, mass media, prefecture, and municipalities in similarity and trust. Items of similarity are "the JMA (government, mass media, prefecture, and municipalities) is providing aftershock information from a viewpoint similar to that of residents" and "the JMA (government, mass media, prefecture, and municipalities) understands the effect of aftershock information on residents" (the JMA: $\alpha = .81$, government: $\alpha = .92$, mass media: $\alpha = .94$, prefecture: $\alpha = .95$, and municipalities: $\alpha = .97$). Items of trust are "the JMA (government, mass media, prefecture, and municipalities) has the ability to properly communicate aftershock information" and "the JMA (government, mass media, prefecture, and municipalities) communicates aftershock information with a consideration for residents' safety" (the JMA: $\alpha = .84$, government: $\alpha = .88$, mass media: $\alpha = .90$, prefecture: $\alpha = .89$, and municipalities: $\alpha = .91$).

## 3. Result

### 3.1. Analysis of Reasons for Evacuation Decision in Foreshock and Main Shock

A logistic regression analysis was conducted to examine the reasons affecting evacuation action decisions after the foreshock. The stepwise method was used in the analysis with a dependent variable of whether they took evacuation actions after the foreshock, and independent variables of age, sex, and reasons for evacuating (or not evacuating) from the list of 31 items. **Table 1** shows the reasons of statistically significant effects on evacuation decisions after the foreshock. **Fig. 1(a)** shows the odds rates in the vertical axis in the order of the degree of promotion and suppression. In the case of foreshock, "anxiety for building safety" and "fear for aftershock" were ma-




Note: "41.53" of the item "anxiety for building safety" for evacuation after the foreshock means, for example of odds ratio, those who selected this reason will be 41.53 times as likely to evacuate compared to those who did not select this reason. Similarly, "0.20" for "advice from neighbors" means that those who selected this reason will be 0.20 times as likely as to evacuate compared to those who did not select this reason.

**Fig. 1.** Odds rates of reasons for evacuation decisions in the foreshock and main shock.

**Table 2.** Results of the logistic regression analysis of reasons for evacuation decision in the main shock.

| | B | Wald | odds rate | LL95%CI | UL95%CI |
|---|---|---|---|---|---|
| Advice from neighbors | 2.66 | 11.95 ** | 14.34 | 3.17 | 64.92 |
| Evacuation instruction (recommendation) received | 2.19 | 27.85 ** | 8.97 | 3.97 | 20.25 |
| Fear for aftershocks | 1.99 | 196.54 ** | 7.32 | 5.54 | 9.66 |
| Anxiety for building safety | 1.67 | 94.52 ** | 5.33 | 3.81 | 7.47 |
| Just wanted to meet people | .97 | 6.92 ** | 2.62 | 1.28 | 5.38 |
| Public services as power, gas, and water interrupted | .74 | 15.33 ** | 2.10 | 1.45 | 3.04 |
| Alarm of earthquake early warning | .55 | 4.49 * | 1.73 | 1.04 | 2.88 |
| Age | .01 | 5.78 * | 1.01 | 1.00 | 1.02 |
| Failure to evacuate against the will | -1.60 | 13.11 ** | .20 | .09 | .48 |
| No damage of building | -1.55 | 54.23 ** | .21 | .14 | .32 |
| No need to evacuate | -1.44 | 28.07 ** | .24 | .14 | .40 |
| Administrative supports expected | -.68 | 4.03 * | .51 | .26 | .98 |
| Staying was felt safer | -.66 | 22.47 ** | .52 | .39 | .68 |
| Public services such as power, gas, and water | -.60 | 7.00 ** | .55 | .35 | .86 |
| Intercept | -.51 | 4.58 * | .60 | | |
| log likelihood | 1559.4 | | | | |
| Cox and Shell $R^2$ | .41 | | | | |
| Nagelkerke $R^2$ | .64 | | | | |

$*p < .05, **p < .01$

jor reasons that attributed to an increase in the probability of respondents taking evacuation actions, in addition to "advice from neighbors." On the other hand, those who selected "failure to evacuate against the will" and "information from SNS (Twitter, Facebook, and so on)" were less likely to take evacuation actions. As well, "No damage of buildings" and "No need to evacuate" were reasons for reducing the probability of taking evacuation actions. However, the influence of "information from SNS" was unexpected.

Similarly, a logistic regression analysis was conducted using the stepwise method on reasons for evacuation actions after the main shock. **Table 2** shows reasons of statistically significant effects on evacuation decisions after

**Table 3.** Gender and age in the groups of evacuation patterns.

| | Gender | | Age | |
|---|---|---|---|---|
| | Male | Female | Mean | SD |
| No evacuation ($n$=526) | 55% | 46% | 53.87 | (15.90) |
| Evacuation after the foreshock($n$=964) | 44% | 56% | 50.39 | (14.80) |
| Evacuation after the main shock($n$=147) | 42% | 58% | 49.48 | (15.86) |
| Evacuation after both shocks($n$=1396) | 42% | 58% | 53.91 | (16.79) |
| | $\chi^2(3) = 21.63$, $p < .01$ | | $F(3,3029) = 12.27$, $p < .01$, $\eta^2 = .01$ | |

the main shock. **Fig. 1 (b)** shows the odds rates in the vertical axis in the order of the degree of promotion and suppression. In the case of main shock, "advice from neighbors" is the most influential reason for taking evacuation actions, followed by "evacuation instruction (recommendation)" and "fear for aftershocks." Reasons that reduced the probability of taking evacuation actions were "failure to evacuate against the will," "no damage of buildings," and "no need for evacuation." The influence of SNS was not found in the case of the main shock.

## 3.2. Evacuation Patterns

Evacuation action patterns were categorized to examine the effect of evacuation actions after the foreshock and main shock on subsequent risk perception, similarity, and trust. Residents who took evacuation actions after the foreshock and main shock were categorized into the "group of evacuation after both shocks," while those who took evacuation actions only after the main shock were categorized into the "group of evacuation after the main shock." Residents who took evacuation actions only after the foreshock were categorized into the "group of evacuation after the foreshock," and those who did not take evacuation actions after either of the shocks were categorized into the "group of no evacuation." **Table 3** shows attributes such as age and gender for each group. There are statistical differences in the age and gender among the four groups because the sample size is large. Therefore, the accuracy of analysis is maintained when interpreting by inputting age and gender as controlled variables to control their effects so that biased results are not generated.

### 3.2.1. Effect of Evacuation Patterns on Risk Perception

The effect of evacuation action patterns during the Kumamoto earthquake on earthquake risk perception (severity, knowledge, and uncertainty) is examined. As control variables, age, gender, property damage, and human suffering were inputted. First, the analysis result of a general linear model using the dependent variable of severity showed the main effect of evacuation action patterns, damage of property, and human suffering (**Table 4**). As a result of multiple comparisons of the main effects of evacuation patterns using the Bonferroni method, a difference was found between the group of evacuation after both shocks ($M = 4.74$, $SD = .57$), and the group of evacuation after the main shock ($M = 4.69$, $SD = .51$), and the group of no evacuation ($M = 4.58$, $SD = .68$). In addition, with greater damage of property ($\beta = .07$, $p < .001$) and human suffering ($\beta = .08$, $p = .002$), the perception of the severity increases.

**Table 4.** GLM analysis of risk perception.

| | Severity | Knowledge | Uncertainty |
|---|---|---|---|
| | F value | F value | F value |
| Evacuation pattern | 4.15 ** | 4.72 ** | 2.27 |
| Age | 2.25 | 11.84 ** | 10.00 ** |
| Gender | 1.71 | .88 | 3.82 |
| Damage of property | 25.71 ** | 1.66 | .00 |
| Human suffering | 9.41 ** | 4.43 * | 2.95 |
| Mean | 4.69 | 2.94 | 4.74 |
| SD | .57 | .75 | .47 |

* $p < .05$, ** $p < .01$

Second, the analysis result of a general linear model using the dependent variable of knowledge showed the main effects of evacuation action patterns, property damage, and human suffering. As a result of multiple comparisons of the main effects of evacuation patterns using the Bonferroni method, a difference was found between the group of evacuation after the main shock ($M = 2.84$, $SD = .71$), and the group of evacuation after both shocks ($M = 2.97$, $SD = .76$). In addition, at older ages ($\beta = .003$, $p < .001$) and greater human suffering ($\beta = -.08$, $p = .035$), the perception of the sense of knowing increases.

Finally, the analysis result of a general linear model using the dependent variable of uncertainty showed the main effect of age. With older ages ($\beta = -.002$, $p < .001$), the perception of uncertainty increases.

**Table 5.** GLM analysis of similarity.

| | JMA | Government | Media | Prefecture | Municipality |
|---|---|---|---|---|---|
| | F value | F value | F value | F value | F value |
| Evacuation pattern | 3.93 ** | 3.04 * | 4.77 ** | 5.14 ** | 2.24 |
| Age | 144.68 ** | 116.65 ** | 216.55 ** | 11.28 ** | 4.65 * |
| Gender | .25 | 1.06 | 6.68 * | 12.55 ** | 6.00 * |
| Damage of property | .04 | .03 | 1.42 | 3.07 | 3.43 |
| Human suffering | 13.53 ** | 6.80 ** | 2.17 | 4.56 * | 9.09 ** |
| Mean | 3.23 | 3.04 | 3.04 | 3.40 | 3.27 |
| SD | .93 | .94 | 1.01 | .93 | 1.00 |

* $p < .05$, ** $p < .01$

### 3.2.2. Effect of Evacuation Patters on Similarity

The effect of different evacuation action pattern experience on similarity for entities related to earthquake risk communication (the JMA, government, mass media, prefecture, municipalities) is examined. Age, gender, and damage of property and human suffering owing to the Kumamoto earthquake were input as control variables as they were in the case of risk perception. First, the analysis results using a general linear model with dependent variable of similarity of the JMA show the main effects of evacuation action patterns, age, and human suffering (**Table 5**). As a result of multiple comparisons of the main effects of evacuation patterns using the Bonferroni method, a difference was found between the group of evacuation after both shocks ($M = 3.27$, $SD = .93$) and the group of evacuation after the main shock ($M = 3.11$, $SD = .90$). In addition, at older ages ($\beta = .01$, $p < .001$) and smaller human suffering ($\beta = -.15$, $p < .001$), similarity increases.

Second, the analysis results using a general linear model with the dependent variable of similarity of the government show the main effects of evacuation action patterns, age, and human suffering. As a result of multiple comparisons of the main effects of evacuation patterns using the Bonferroni method, major differences were not found. In addition, at older ages ($\beta = .01$, $p < .001$) and smaller human suffering ($\beta = -.11$, $p = .009$), the similarity increases.

Third, the analysis results using a general linear model with the dependent variable of similarity of mass media show the main effects of evacuation action patterns, age, and human suffering (**Table 5**). As a result of multiple comparisons of the main effects of evacuation patterns using the Bonferroni method, a difference was found between the group of evacuation after both shocks ($M = 3.08$, $SD = 1.02$) and the group of evacuation after the main shock ($M = 2.89$, $SD = .96$). In addition, at older ages ($\beta = .02$, $p < .001$) and with female respondents ($\beta = .10$, $p = .010$), the similarity perception increases.

Forth, the analysis results using a general linear model with the dependent variable of similarity of the Kumamoto Prefecture show the main effects of evacuation action patterns, age, and human suffering. As a result of multiple comparisons of the main effects of evacuation patterns using the Bonferroni method, a difference was found between the group of evacuation after both shocks ($M = 3.45$, $SD = .92$) and the group of evacuation after the main shock ($M = 3.31$, $SD = .90$). In addition, at older ages ($\beta = .004$, $p < .001$), with female respondents ($\beta = .13$, $p < .001$), and with smaller human suffering ($\beta = -.09$, $p = .033$), the similarity perception increases.

Finally, the analysis results using a general linear model with the dependent variable of similarity of municipalities show the main effects of age, gender, and human suffering. At older ages ($\beta = .003$, $p < .001$), with female respondents ($\beta = .09$, $p = .019$), and with smaller human suffering ($\beta = -.13$, $p = .003$), the similarity perception increases.

### 3.2.3. Effect of Evacuation Patterns on Trust

The effects of different evacuation action pattern experiences on trust perception for entities related to earthquake risk communication (the JMA, government, mass media, prefecture, municipalities). Age, gender, and property and human damage owing to the Kumamoto earthquake were input as control variables as they were in the case of risk perception. In addition, similarity as a determinant of trust was input into the model as an independent variable including the interaction term with evacuation patterns. First, the analysis results using a general linear model with dependent variables of trust of the JMA show the main effect of similarity only (**Table 6**). With higher similarity ($\beta = .74$, $p < .001$), trust increases.

Second, the analysis results using a general linear model with the dependent variables of trust of the government show the main effect of similarity only. With higher similarity ($\beta = .73$, $p < .001$), trust increases.

Third, the analysis results using a general linear model with the dependent variable of trust of mass media show the main effect of similarity only. With higher similarity ($\beta = .74$, $p < .001$), the trust increases.

Forth, the analysis results using a general linear model with the dependent variable of trust of the Kumamoto Prefecture show the main effects of similarity and age. With

**Table 6.** GLM analysis of trust.

| | JMA | Government | Media | Prefecture | Municipality |
|---|---|---|---|---|---|
| | F value | F value | F value | F value | F value |
| Evacuation pattern | .30 | .09 | 1.31 | .34 | 1.61 |
| Age | 3.63 | 1.25 | 1.04 | 5.35 * | 7.06 ** |
| Gender | .56 | 1.69 | 1.00 | .61 | .27 |
| Damage of property | 2.02 | .17 | .01 | .40 | 5.97 * |
| Human suffering | 1.30 | 3.15 | 3.56 | .98 | 3.39 |
| Similarity | 1424.23 ** | 1769.74 ** | 1913.39 ** | 1956.40 ** | 2382.06 ** |
| Evacuation pattern ×Similarity | 1.38 | 2.28 | .20 | .65 | .70 |
| Mean | 3.43 | 3.23 | 3.24 | 3.36 | 3.12 |
| SD | .95 | .95 | .99 | .92 | 1.01 |

* $p < .05$, ** $p < .01$

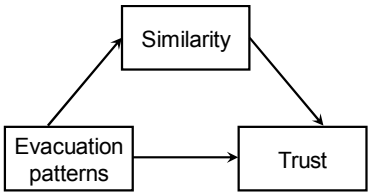



**Fig. 2.** Process analysis model of meditated effect by similarity.

**Table 7.** The indirect effect of evacuation patterns on trust via similarity.

| | B | LL95%CI | UL95%CI |
|---|---|---|---|
| JMA | .004 | .0004 | .01 |
| Government | .003 | .00004 | .01 |
| Media | .006 | .001 | .01 |
| Prefecture | .003 | .0002 | .01 |

Note: The interval estimation of coefficients is significant as long as 0 is not included between LL95% and UL95%.

higher similarity ($\beta = .77$, $p < .001$) and at older ages ($\beta = .002$, $p = .021$), the trust increases.

Finally, the analysis results using a general linear model with the dependent variable of trust of municipalities show the main effects of similarity, age, and property damage. With higher similarity ($\beta = .82$, $p < .001$), at older ages ($\beta = .002$, $p = .008$), and with smaller damage of property ($\beta = -.04$, $p = .015$), the trust increases.

As shown above, trust is mainly determined by similarity perception, which is different depending on evacuation action patterns except for those in municipalities. Therefore, the indirect influential relationship of evacuation patterns and similarity and trust is examined (**Fig. 2**). A process analysis [20] was implemented to examine the intermediate effect on trust, except for municipalities that showed no effect of evacuation action patterns on similarity. The bias-corrected bootstrap method with a resample scale of $n = 50,000$ was used as an interval estimation of the indirect effect. First, the indirect effect via the similarity of evacuation actions on the trust on the JMA was found (**Table 7**). Trust of the group of evacuation after the foreshock ($\beta = -.15$, 95%LCI $= -.26$, 95%UCI $= -.02$) and of the group of evacuation after the main shock ($\beta = -.11$, 95%LCI $= -.16$, 95%UCI $= -.06$) was lower than that of the group of evacuation after both shocks. Second, the indirect effect via the similarity of evacuation actions on the trust on the government was found. Trust of the group of evacuation after the foreshock ($\beta = -.17$, 95%LCI $= -.30$, 95%UCI $= -.04$) and of the group of evacuation after the main shock ($\beta = -.09$, 95%LCI $= -.15$, 95%UCI $= -.03$) was lower than that of the group of evacuation after both shocks. Third, the indirect effect via the similarity of evacuation actions on the trust on mass media was found. Trust of the group of evacuation after the main shock ($\beta = -.15$, 95%LCI $= -.22$, 95%UCI $= -.10$) and of the group of no evacuation ($\beta = -.09$, 95%LCI $= -.17$, 95%UCI $= -.01$) was lower than the trust of the group of evacuation after both shocks. Finally, the indirect effect via the similarity of evacuation actions on the trust on Kumamoto Prefecture was found. Trust of the group of evacuation after the foreshock ($\beta = -.14$, 95%LCI $= -.28$, 95%UCI $= -.01$) and of the group of evacuation after the main shock ($\beta = -.11$, 95%LCI $= -.17$, 95%UCI $= -.05$) was lower than the trust of the group of evacuation after both shocks.

## 4. Discussion

This study investigated characteristics of evacuation actions after the foreshock and main shock based on residents' reasons and the effect of evacuation action patterns on subsequent risk perception and similarity and trust perception on entities of risk communication.

### 4.1. Differences of Reasons Between Foreshock and Main Shock Evacuations

There was a difference in the reasons for decision to evacuate actions after the foreshock and main shock. After the foreshock, anxiety for buildings and fear for aftershocks were the main reasons for evacuation. After the main shock, instead of these reasons, advice from neighbors was the main reason for evacuation actions. In general, people feel great anxiety during a large disaster such as the Kumamoto earthquake. As in past cases [3], such anxiety seems to have been the driving factor for evacuation actions after the foreshock.

However, in the case of the Kumamoto earthquake, the greater main shock was experienced after the foreshock. This was an unexpected circumstance for many victims, which generated more feelings of anxiety. It has been suggested that individual judgement and decision-making abilities are impaired as a result. This can be observed in cases of disorientation when strong anxiety is felt [21]. Therefore, under circumstances involving impaired judgement ability and strong anxiety due to the main shock, advice from neighbors that encouraged evacuation may be the determinant for evacuation action.

On the other hand, the SNS information provision was a reason for not taking evacuation actions in addition to effectiveness and necessity of evacuation. Selective information usage [22] may be the psychological mechanism that allowed SNS to suppress evacuation actions. Evacuation may have been suppressed because those who were hesitating to evacuate selectively used similar opinions on SNS when judging the severity of the situation. In addition, safety information about family members and acquaintances may have acted as a kind of normalcy bias [23] that aided in false perceptions about one's own circumstances.

In a case involving SNS communication during the Great East Japan Earthquake, it was pointed out that those who acquired information by using SNS tended to acquire rumors [5]. However, whether the same tendency existed during the Kumamoto earthquake is a case that must be carefully interpreted because the scale of disaster is different, and such a case did not target victims. In addition, the effects of SNS on evacuation decisions were found only for foreshock evacuations. The strategy of information selection may have been altered through the experience of the main shock. The present research is a case study. Whether SNS can be a factor that suppresses evacuation actions in other disasters is a question that should be studied.

### 4.2. The Influences of Evacuation Patterns on Risk Perception

A difference in evacuation action patterns was confirmed in the aspects of the severity and knowledge in relation to earthquake risk perception. For both of those aspects, the group of evacuation after the main shock relatively highly evaluated risks compared to the group of evacuation after both shocks. In other words, the unexpected experience of the earthquake (evacuation first occurring after the main shock) tended to increase perception of severity and reduce the perception of knowledge. Judgement based on one's own experience is an experiential decision-making (System 1) of risk perception rather than an analytic decision-making (System 2) [24].

Previous study has suggested that the judgement practices involved in System 1 dominate the fear aspect of risk perception [25]. In this study, perception of the severity (huge damage may occur) and knowledge (the situation can be addressed scientifically) is readily linked to the sense of fear. This means that the experience of evacuation actions had an impact. On the other hand, the uncertainty aspect of risk perception was not affected by evacuation actions because logical judgement, such as ascertaining the predictability of an earthquake, is required, and the judgement process involved in System 2 can be reflected. As such, the effect of evacuation actions differs depending on the judgement characteristics of risk perception.

### 4.3. Influence of Evacuation Patterns on Similarity and Trust

Differences in the evacuation action patterns were found for the similarity of the JMA, government, mass media, and prefecture. In particular, the similarity of the JMA, mass media, and prefecture was perceived as being lower by the group of evacuation after the main shock than by the group of evacuation after both shocks. Similarity was salient for organizations with lower trust during the Great East Japan Earthquake [16]. In the present study, for residents who did not evacuate after the foreshock but did after the unexpected main shock, the experience of the Kumamoto earthquake may reduce the level of public trust in risk communication organizations. In such a situation, the similarity as an antecedent was probably reduced. On the other hand, evacuation action patterns did not affect the perception of similarity of municipalities. This seems to be because municipalities were forefront organizations that directly supported the affected residents.

Next, regarding trust of the JMA, government, mass media, and the Kumamoto Prefecture, the indirect effect of evacuation action patterns via similarity was found rather than a direct effect of the difference in evacuation action patterns. Previous studies indicated that organizations maintained trust before and after the Great East Japan Earthquake [17, 18]. In addition, the similarity is likely to become salient with decreasing trust [16]. In the case of the Kumamoto earthquake, the effects of similarity for each entity became salient and altered trust. The main effect of evacuation action patterns on trust was that trust of the groups of evacuation after the foreshock and after the main shock was smaller than that of the group of evacuation after both shocks. In other words, those who evacuated after the foreshock and main shock originally placed trust in risk communication entities. As a result of taking evacuation actions, a certain level of safety was assured, and trust was therefore strengthened. Mean-

while, those who took evacuation action after either the foreshock or the main shock were forced to take actions by the earthquake itself. As a result of this inconvenience, the trust placed in organizations was impaired. Effects of evacuation action patterns on trust may be resulted from emotional reactions because evacuation action patterns affected trust not directly, but via similarity as a psychological factor. However, the trust of mass media was an exceptional reaction. Trust of the group of evacuation after both shocks was higher than that of the group of evacuation after the main shock and no evacuation. The reason for this is assumed to be that the group of evacuation after both shocks tended to act following media information. Psychologically, people form cognitions consistent with their actions [26]. Trust may have been strengthened as a result of evacuating following media information after the foreshock and main shock.

## 5. Conclusions

The Kumamoto earthquake is a disaster case in which a foreshock of Mj6.5 was soon followed by a greater main shock of Mj7.3. Residents seem to have been forced to address unexpected circumstances because the reasons for evacuation decision actions after the foreshock and main shock differed. If the scientific understanding of natural disasters advances, the occurrence of natural disasters cannot be controlled. How people react to such natural phenomenon is an important issue in situations involving disaster risk management [2]. The Kumamoto earthquake is a precious case in which people reacted to an unexpected earthquake disaster that continuously occurred over a short period of time.

In the framework of social risk amplification, reactions to risks are considered to amplify or diminish based on interactions of the magnitude of hazards and social contexts such as experience and values [9, 10]. In particular, social discussions about the information provision on aftershock probability occurred after the Kumamoto earthquake[6, 7]. In reality, the reactions to risks differed depending on evacuation action patterns after the foreshock and main shock. However, effects such as a severe decrease in the trust of risk communication entities such as the JMA and government were not discovered.

On the other hand, the effect of similarity became salient on risk communication entities as a determinant of trust. The effect of similarity on risk communication entities became salient in the case of the Great East Japan Earthquake [16] as in the case of the Kumamoto earthquake. Therefore, the aspect of similarity (whether a similar organizational viewpoint is shared with residents) in unexpected disasters is important in actual risk communication. Note that factors such as risk perception, similarity, and trust have been affected by disasters that occurred before the Kumamoto earthquake. The present research results must not be understood as a simple causal relationship. As well, study from extensive viewpoints including the formation of these factors before the disaster is required.

In addition to the above discussions, there are some limitations of this study. First, the data were collected about eight months after the Kumamoto earthquake occurred. Therefore, there is a limitation when studying the situation involving the days during the earthquake. Second, the specific contents of communication about evacuation reasons with neighbors and on SNS was not included in the research data. While the effectiveness of SNS as a rescue tool during a disaster has been suggested, unexpected problems due to information diffusion have been reported [27]. When considering information diffusion processes, the contents of communication among residents during a disaster is an issue that requires study. People who have risk literacy can make judgements that are less dependent on circumstances [11]. Including the SNS usage method during a disaster, education about risk literacy and disaster management literacy [28] is required as a risk management tool for unexpected disasters.

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**References:**

[1] N. N. Taleb, The Black Swan: The Impact of the Highly Improbable, NY: Random House, 2007.

[2] J. Mochizuki, and N. Komendantova, "In Search of Perfect Foresight? Policy Bias, Management of Unknowns, and What Has Changed in Science Policy since the Tohoku Disaster," Risk Analysis, Vol.37, No.2, pp. 219-230, 2017. doi:10.1111/risa.12602.

[3] R. Kimura, H. Hayashi, S. Tatsuki, K. Tamura, K. Horie, and A. Kuromiya, "Defined Evacuation and Sheltering Processes of Disaster Victims in the 2004 Mid-Niigata Prefecture Earthquake," J. of Social Safety Science, Vol.7, pp. 161-170, 2005.

[4] Hyogo prefecture, "Report on The Results of Survey on Living Reconstruction in 2005," Retrieved from https://web.pref.hyogo.lg.jp/kk41/documents/000043904.pdf, 2005 [in Japanese, accessed Aug. 1, 2017]

[5] A. Miura, "Social Psychology of Online Communication on 3.11 Disasters in Japan," The J. of the Institute of Electronics, Information, and Communication Engineers, Vol.95, No.3, pp. 219-223, 2012/03/01, 2012.

[6] Mainichi-Shinbun, "The Japan Meteorological Agency discontinued Announcing The Probability of Aftershock Occurrences in The 2016 Kumamoto Earthquake Because There is No Precedent," Mainichi-Shinbun, 26th April, morning editon, 2016 [in Japanese, accessed Aug. 1, 2017]

[7] Yomiuri-Shinbun, "Discontinue Announcing The Probability of Aftershock Occurrences in The 2016 Kumamoto Earthquake, "Do Not Apply to Experience" The Japan Meteorological Agency," Yomiuri-Shinbun, 21st April, morning edition, 2016 [in Japanese, accessed Aug. 1, 2017]

[8] J. Michailova, T. Tyszka, and K. Pfeifer, "Are People Interested in Probabilities of Natural Disasters?," Risk Analysis, Vol.37, No.5, pp. 1005-1017, 2017. doi:10.1111/risa.12685.

[9] R. E. Kasperson, O. Renn, P. Slovic, H. S. Brown, J. Emel, R. Goble, J. X. Kasperson, and S. Ratick, "The Social Amplification of Risk: A Conceptual Framework," Risk Analysis, Vol.8, No.2, pp. 177-187, 1988. doi:10.1111/j.1539-6924.1988.tb01168.x.

[10] O. Renn, W. J. Burns, J. X. Kasperson, R. E. Kasperson, and P. Slovic, "The Social Amplification of Risk: Theoretical Foundations and Empirical Applications," J. of Social Issues, Vol.48, No.4, pp. 137-160, 1992. doi:10.1111/j.1540-4560.1992.tb01949.x.

[11] T. Kusumi, R. Hirayama, and Y. Kashima, "Risk Perception and Risk Talk: The Case of the Fukushima Daiichi Nuclear Radiation Risk," Risk Analysis, 2017. doi:DOI: 10.1111/risa.12784.

[12] T. Kinoshita, "Thought and Technology of Risk and Communication," Kyoto: Nakanishiya, 2016.
[13] P. Slovic, "Perception of Risk," Science, Vol.236, No.4799, pp. 280-285, 1987. doi:10.1126/science.3563507.
[14] T. C. Earle, and G. Cvetkovich, Social Trust: Toward a Cosmopolitan Society, Westport, CT: Praeger Press, 1995.
[15] M. Siegrist, T. C. Earle, and H. Gutscher, "Test of a Trust and Confidence Model in the Applied Context of Electromagnetic Field (Emf) Risks," Risk Analysis, Vol.23, No.4, pp. 705-716, 2003. doi:10.1111/1539-6924.00349.
[16] K. Nakayachi, D. Kudo, and T. Ozaki, "Trust in Organizations Concerned with Risks of the Great East Japan Earthquake," The Japanese J. of Psychology, Vol.85, No.2, pp. 138-147, 2014. doi:10.4992/jjpsy.85.13014.
[17] S. Ohtomo, H. Osawa, Y. Hirose, and S. Ohnuma, "The Impacts of Fukushima Nuclear Accident on Public Acceptance of Geological Disposal of High Level Radioactive Waste," Japanese J. of Risk Analysis, Vol.24, No.1, pp. 49-59, 2014. doi:10.11447/sraj.24.49.
[18] V. H. M. Visschers, and M. Siegrist, "How a Nuclear Power Plant Accident Influences Acceptance of Nuclear Power: Results of a Longitudinal Study before and after the Fukushima Disaster," Risk Analysis, Vol.33, No. 2, pp. 333-347, 2013. doi:10.1111/j.1539-6924.2012.01861.x.
[19] MEXT (Ministry of Education, Sports, Science and Technologyof Japan), Survey Study About the Effect of Information of Aftershock and Impact on Evacuation Activities in the 2016 Kumamoto Earthquake, 2017.
[20] K. Preacher, and A. Hayes, "Asymptotic and Resampling Strategies for Assessing and Comparing Indirect Effects in Multiple Mediator Models," Behavior Research Methods, Vol.40, No.3, pp. 879-891, 2008/08/01, 2008. doi:10.3758/BRM.40.3.879.
[21] R. Kimura, "Psychology of Disaster, Disaster Prevention," Tokyo: Hokuju, 2015.
[22] W. K. Estes, "The Cognitive Side of Probability Learning," Psychological Review, Vol.83, No.1, pp. 37-64, 1976.
[23] R. H. Turner, "Earthquake Prediction and Public Policy: Distillations from a National Academy of Sciences Report," VMass Emergencies, Vol.1, No. 3, pp. 179–202, 1976.
[24] P. Slovic, "If I Look at the Mass I Will Never Act: Psychic Numbing and Genocide," Judgment and Decision Making, Vol.2, No.2, pp. 79-95, 2007.
[25] M. Siegrist, C. Keller, and M.-E. Cousin, "Implicit Attitudes toward Nuclear Power and Mobile Phone Base Stations: Support for the Affect Heuristic," Risk Analysis, Vol.26, No.4, pp. 1021-1029, 2006. doi:10.1111/j.1539-6924.2006.00797.x.
[26] L. Festinger, "A Theory of Cognitive Dissonance," Stanford University Press, 1962.
[27] J-CAST News, "A Blind Spot of 'good faith' of The Internet Communications in the Torrential Rain in The Kyushu Region," 12th July, 2017, Retrieved from https://www.j-cast.com/2017/07/12303051.html?p=all [in Japanese, accessed Aug. 1, 2017]
[28] R. Kimura, H. Hayashi, K. Kobayashi, T. Nishino, U. Kenshin, and I. Satoshi, "Development of a Disaster Management Literacy Hub for Collecting, Creating, and Transmitting Disaster Management Content to Increase Disaster Management Literacy," J. of Disaster Research, Vol.12, No.1, pp. 42-56, 2017.

## Appendix A. Reasons for Evacuation Decision

Please select all reasons why you evacuated or you did not evacuate from the following list of items.

1 Fear for aftershocks

2 Anxiety for building safety

3 Damage of building

4 Roads blocked

5 Public services as power, gas, and water interrupted

6 No damage of building

7 Staying was felt safer

8 The earthquake was felt insignificant

9 Public services such as power, gas, and water available

10 Elderly family member

11 Infants or children in family

12 Those who need special care in family

13 Pets

14 Just wanted to meet people

15 Information and supplies expected

16 Administrative supports expected

17 Advice from neighbors

18 Advice from family members or relatives

19 Alarm of earthquake early warning

20 Information from TV and radio

21 Information from disaster prevention radio broadcast

22 Information from SNS (Twitter, Facebook, and so on)

23 Evacuation instruction (recommendation) received

24 Evacuation instruction (recommendation) not received

25 Reluctant to evacuate

26 No need to evacuate

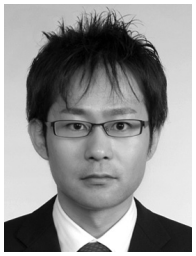
27 Failure to evacuate against the will

28 Rainfall

29 Risk of sediment disaster

30 Volcano eruption anticipated

31 Others



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• "Comparison Between the Life Recovery Processes After the Mid-Niigata Earthquake and the Chuetsu-Oki Earthquake - Results of a Random Sampled Social Survey Using the Life Recovery Calendar and GIS-Based Spatiotemporal Analysis," J. of Disaster Research, pp. 196-203, Vol.10, No.2, Apr., 2015.
• "Issues Facing Voluntary Evacuees from the Fukushima Daiichi Nuclear Power Plant Accident Based on the Collection and Analysis of Cases of Voluntary Evacuation," J. of Disaster Research, Vol.10, No.7 (special edition), pp. 755-769, Sep. 2015.
• "Organizational Structure and Institutions for Disaster Prevention: Research on the 1995 Great Hanshin-Awaji Earthquake in Kobe City," J. of Disaster Research, pp. 1051-1066, Vol.10, No.6, Dec., 2015.
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• N. Hirata, H. Sato, S. Sakai, A. Kato, E. Kurashimo, "Fault system of the 2004 Mid Niigata Prefecture Earthquake and its aftershocks," Landslides, Vol.2, No.2, pp. 153-157, 2005.

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