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Understanding Natech Risk Perception and Adjustment of Households Living near Industrial Areas in Osaka Bay

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Synopsis

This research project collected data based on a stratified random mail survey from two communities in Sakai (Osaka, Japan) and Higashinada (Kobe, Japan) living within two kilometers from industrial parks. The questionnaires focused on household awareness, risk perception and hazard adjustments for earthquakes, tsunamis, and chemical and natural hazard triggered chemical accidents (known as Natech) accidents. Furthermore, we also examined household views (acceptance, trust, and information needed) towards local government and industries' ability to protect them under the risk of earthquake, tsunami, and chemical and Natech accidents. Our findings show that in both surveyed areas, households are well prepared for earthquakes and tsunami, but not for chemical and Natech accidents. Risk perception concerning earthquakes and tsunami were higher in both areas than for chemical and Natech accidents. This study found that households' level of trust in government's ability to protect them under the risk of chemical and Natech accidents was low. Respondents had more trust in local government's ability to protect them against earthquake and tsunami threats. The study results demonstrate the need to provide better information to residents living near industrial parks regarding the risks they are subject to and the types of protective actions they can take if an accident occurs alone or concurrent with an earthquake and/ or tsunami.

Keywords: Natech; risk perception; hazard adjustment; protective behavior; industrial park

1. Introduction

This study assessed household hazard adjustments and risk perception to Natech accidents. Hazard adjustment refers to risk reduction and emergency management interventions to reduce disaster impacts. It includes hazard prevention and mitigation, and emergency and recovery preparedness (Lindell 2013). Several studies have examined factors that affect the adoption of hazard adjustments to earthquake and floods alone; however, very few

studies have looked at conjoint natural and technological (known as Natech) hazards. During a Natech people may be faced with complex situations involving at least two or more hazards simultaneously, requiring specialized knowledge and understanding about the threats, and how to take protective action. In this study, we collected data from two communities in Osaka and Kobe, respectively to explore households' awareness, acceptance, risk perception, preparedness, and trust in government's ability to protect them for the risk of earthquake, tsunami, chemical accident, and Natech accident. Seven research objectives provided the focus for this project:

1. To understand household experiences for the earthquake, tsunami, chemical accident and Natech accident
2. To assess household awareness of the chemical industrial park
3. To identify the factors affecting household perceived Natech risk
4. To understand household acceptance to the chemical accident
5. To understand and assess residents' hazard adjustments for Natech accidents.
6. To understand what information households need if a chemical or Natech accident happens
7. To assess household trust in the government's ability to protect them under the risk of earthquake, tsunami, chemical and Natech accident.

2. Background

Risk perception has been found to be a key factor in motivating hazard adjustments and protective actions (Baker 1991; Sorensen 1991; Riad et al. 1999; Lindell and Perry 2004; Dash and Gladwin 2007; Perry and Lindell 2008; Lindell 2013). Prior perception of personal risk, risk level (hazardousness) of the area, action by public authorities, housing, and specific threat factors were found to largely account for evacuation behavior during hurricanes (Baker 1991). Riad et al. (1999) analyzed why people sometimes decide not to evacuate from a dangerous situation based on a resident interview survey after Hurricanes Hugo and Andrew. They found that not perceiving the hurricane as a threat and believing one's home was a safe place were the most common reasons for not evacuating.

The above studies examined risk perception and protective actions during hurricanes. Only a few studies have analyzed risk perception and protective actions to technological threats. Mileti and Peek (2000) analyzed risk perception formation and public response to warnings of a nuclear power plant emergency. The authors found that the formation of risk perception is guided by the stimulations, cues, etc. that people secure from their environment (e.g., warning information) and that this risk perception formation leads to protective actions. This process is not different than for other types of hazard agents.

The potential influence of risk perception on people's response to Natech accidents has been limited. Indeed, only a few studies have attempted to address this issue. In a contra-factual study, Steinberg et al. (2004) investigated emergency preparedness and earthquake hazard adjustments for the potential impact of an earthquake-induced hazardous materials release from an oil refinery in

a southern California community based on a random telephone survey. Their results showed low chemical and Natech disaster preparedness. Yu, Cruz and Hokugo (2016) studied risk perception and evacuation behavior following the fires at the Sendai Refinery triggered by the Great East Japan earthquake and tsunami on March 11, 2011. The authors found a significant correlation between low risk perception and not evacuating. Concerning protective actions, the study found that households living closer to the industrial park were more likely to evacuate immediately after perceiving the Natech accident, whereas those living further tended to shelter at home.

In Japan there is little or no information provided to residents living near industrial parks concerning the prevention, mitigation and preparedness measures they can take in case of an accident. Thus, understanding their risk perception and hazard adjustment will provide a baseline that will help communities and local government design disaster management plans for these kinds of accidents.

3. Methodology

Survey questionnaires were mailed out to 2000 randomly selected households living near industrial parks on Osaka Bay in Sakai (Osaka, Japan) and Higashinada (Kobe, Japan). A stratified sample was taken according to their distance to the industrial park (D≤700m, 700<D≤1400m, and 1400<D≤2000m). Fig. 1 (Sakai) and Fig.2 (Higashinada) present the areas where we mailed the questionnaires.

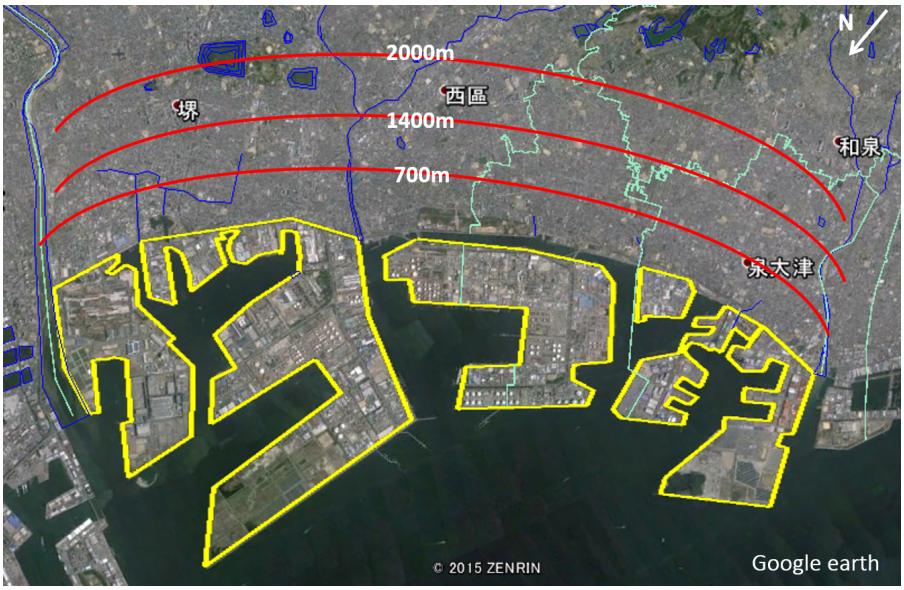

Fig. 1 Map of sending questionnaires (Sakai)

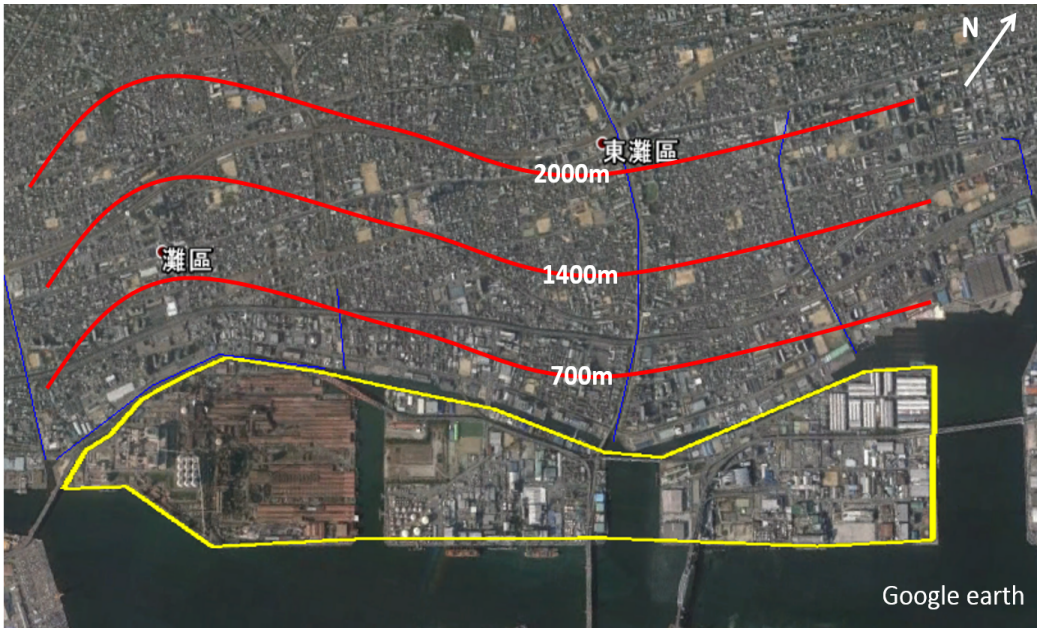

Fig. 2 Map of strata at area sampled in Higashinada Ward, Kobe.

The questionnaires were sent out on November 20, 2015, indicating a due date of December 8, 2015. Due to wrong address or other reasons, 80 questionnaires were not delivered. A total 485 households replied. However, six of these did not finish the questionnaire, by indicating that the house owners (head of household) had passed away. Thus, the total completed questionnaires were 479. See Table 1 indicating the number of mailed, undelivered, and returned questionnaires. The last column in table 1 shows the effective response rates for each strata in each of the two areas. The overall effective response rate for the study is 25%.

4. Results

4. 1 Demographic statistics of respondents

As indicated in Table 2, among the 479 respondents from Sakai and Higashinada areas, 83.7 % (401) of them were men, while only 14.4% (69) of respondents were women. The average age was 68.6 years old. Most respondents were house owners (61.4%), and most of them (63.0%) living in a detached house. The rest are living in concrete (29.2%) and wooden (1.0%) apartment buildings. Almost half of the households (47.2%) were couples and 28.6% were households with two generations. The average family size was 2.6 people per household, and 83.1% of households had no children living at home. Moreover, 75.8% of households had no family members working in an industrial firm handling hazardous substances. 24.8% of respondents have lived in the current house more than 10 years but less than 20 years and 27.3% more than 40 years. Almost half of respondents (43.4%) had no job. Others included clerks (21.9%), business owners (7.1%), and housewives (5.0%). 37.2% households had monthly income between 200,000-400,000 yen. 22.4% households reported incomes of more than 600,000 yen per month.

Table 1. Number of mailed, undelivered and completed questionnaires as well as the effective response rate for each segment in Sakai and Higashinada areas.

	Distance (D)	Sent	Undelivered	Completed	Response rate
Sakai Area	D≤700m	400	15	93	24%
	700<D≤1400m	300	3	81	27%
	1400<D≤2000m	300	10	69	24%
Higashinada Area	D≤700m	400	28	107	29%
	700<D≤1400m	300	11	69	24%
	1400<D≤2000m	300	13	60	21%
Total		2000	80	479	25%

Almost half of the households (47.2%) were couples. 28.6% were households with two generations. The average family size was 2.6 people per household, and 83.1% of households had no children living in the current house. Moreover, 75.8% of households had no family members working in an industrial firm handling toxic or flammable substances. The majority of respondents have lived in the current house more than 10 years but less than 20 years (24.8%), or more than 40 years (27.3%). Almost half of respondents (43.4%) had no job. The rest were clerks (21.9%), business owners (7.1%), housewives (5.0%), and others (9.4%). 37.2% of respondents reported income between 200,000 and 400,000 yen per month. 22.4% of respondents reported incomes of more than 600,000 yen per month.

Table 2. Demographic statistics of respondents

	Sakai Area	Higashinada Area	Total
Gender			
Male	211(86.8%)	190(80.5%)	401(83.7%)
Female	27(11.1%)	42(17.8%)	69(14.4%)
No answer	5(2.1%)	4(1.7%)	9(1.9%)
Average age	68.6	68.6	68.6
Average family size	2.7	2.4	2.6
House ownership			
Yes	172(70.8%)	122(51.7%)	294(61.4%)
No	59(24.3%)	96(40.7%)	155(32.4%)
No answer	12(4.9%)	18(7.6%)	30(6.3%)
House type			
Detached house	175(72.0%)	127(53.8%)	302(63.0%)
Apartment (concrete)	51(21.0%)	89(37.7%)	140(29.2%)
Apartment (wooden)	4(1.6%)	1(0.4%)	5(1.0%)

Other	1(0.4%)	1(0.4%)	2(0.4%)
No answer	12(4.9%)	18(7.6%)	30(6.3%)
Household size			
Single	32(13.2%)	32(13.6%)	64(13.4%)
Couple	107(44.0%)	119(50.4%)	226(47.2%)
2 generations	78(32.1%)	59(25.0%)	137(28.6%)
3 generations	12(4.9%)	6(2.5%)	18(3.8%)
4 generations	3(1.2%)	0(0.0%)	3(0.6%)
No answer	11(4.5%)	20(8.5%)	31(6.5%)
Have children in the family			
Yes	18(7.4%)	14(5.9%)	32(6.7%)
No	197(81.1%)	201(85.2%)	398(83.1%)
No answer	28(11.5%)	21(8.9%)	49(10.2%)
Have family members working in the industrial firm handling hazardous substances			
Yes	51(21.0%)	32(13.6%)	83(17.3%)
No	179(73.7%)	184(78.0%)	363(75.8%)
No answer	13(5.3%)	20(8.5%)	33(6.9%)
Residency length			
≤10 years	14(5.8%)	26(11.0%)	40(8.3%)
>10≤20 years	57(23.5%)	62(26.3%)	119(24.8%)
>20≤30 years	30(12.3%)	47(19.9%)	77(16.1%)
>30≤40 years	42(17.3%)	42(17.8%)	84(17.5%)
>40 years	89(36.7%)	42(17.8%)	131(27.3%)
No answer	11(4.5%)	17(7.2%)	28(5.8%)
Income(per month)			
≤200,000yen	38(15.6%)	25(10.6%)	63(13.1%)
>200,000≤400,000 yen	85(35.0%)	93(39.4%)	178(37.2%)
>400,000≤600,000 yen	34(14.0%)	48(20.3%)	82(17.1%)
>600,000 yen	61(25.1%)	46(19.5%)	107(22.4%)
No answer	25(10.3%)	24(10.2%)	49(10.2%)
Occupation			
Housewife	11(4.5%)	13(5.5%)	24(5.0%)
Clerk	55(22.6%)	50(21.2%)	105(21.9%)
Own business	22(9.1%)	12(5.1%)	34(7.1%)
No job	101(41.36%)	107(45.3%)	208(43.4%)
Others	23(9.5%)	22(16.1%)	45(9.4%)
No answer	31(12.8%)	63(13.2%)	63(13.2%)

4. 2 Experience

Respondents were asked if they had experienced an earthquake, tsunami or chemical accident. If so, they were also asked the year of their most recent experiences. If no, they were also asked to indicate if they could see the fire or smell the smoke from the chemical industrial park often or occasionally. We also asked respondents to tell us if they had participated any work shop and/or training courses on earthquake, tsunami, chemical accident, and Natech accident organized by industries or local government.

The results are shown in Table 3. It shows that in both Sakai and Higashinada areas, most respondents had experienced earthquake (40.0% and 71.0%, respectively), while few of them experienced tsunami or chemical accident in both investigated areas. Even so, 16.5% and 21.0% of respondents in Sakai area said they could see the fire or smell the smoke from the chemical industrial park often and occasionally, respectively. In comparison, respondents in Higashinada area rarely observed the dangerous phenomenon (only 2.5% of them indicated they could occasionally see the fire or smell the smoke from the chemical industrial park). Furthermore, 32.5% of respondents from Sakai area and 25.8% from Higashinada area had never experienced earthquake, tsunami or chemical accident. Moreover, most respondents reported that the most recent earthquake experience was during the Great Hanshin- Awaji Earthquake, 1995.

Higher percentage of respondents in Sakai area than in Higashinada area had attended workshop and/or training courses for the earthquake, tsunami, chemical accident, and Natech accident. In both areas, earthquake workshop and/or training course were the most popular programs (participation rates were 44.0% and 29.7%, respectively), following the tsunami activities (participation rates were 38.7% and 13.1%, respectively). In comparison, very few respondents had attended the workshop and/or training programs for the chemical accident and Natech accident. In Sakai area, only 5.3% of respondents had attended chemical accident programs, while 6.2% of them had attended the programs for the Natech accident. In the Higashinada area, the situation is even worse. Only 1.7% and 2.1% of respondents said they had attended the workshop and/or training courses for the chemical and Natech accident, respectively.

Table 3. Respondents' past experience and attendance to workshop/training courses for the earthquake, tsunami, chemical accident and Natech accident.

Experience	Sakai Area	Higashinada Area
No. of respondents	243	236
Earthquake	39.9%	70.8%
Tsunami	0.8%	0.8%
Chemical accident	6.2%	5.1%
No, but I often see the fire or smell smoke coming from the industrial park	16.5%	0.0%

No, but I occasionally see the fire or smell smoke coming from the industrial park	21.0%	2.5%
Never	32.5%	25.8%
Workshop/Training course		
Earthquake	44.0%	29.7%
Tsunami	38.7%	13.1%
Chemical accident	5.3%	1.7%
Natech accident	6.2%	2.1%

※ multiple choices are possible

4. 3 Awareness

We used two ways to measure respondents' awareness of the presence of a chemical industrial park near their homes. First, we asked respondents if they knew of the existence of a chemical industrial park near their living homes. Second, we asked respondents to provide an estimate of the distance from their homes to the chemical industrial park (≤ 500m； >500m≤ 1km; >1m≤ 1.5km; >1.5km≤ 2km; and I don't know).

Results in Figure 3 show that a higher percentage of respondents in the Sakai area (84.8%) were aware of the existence of a chemical industrial park near their homes, as compared to respondents in the Higashinada area (36.4%). This may be because less percentage of respondents from Higshinada area had experienced a chemical/ Natech accident, or observed any dangerous phenomena from the chemical industrial park (see Table 3).

As Fig.4 shows, the percentage of not knowing the chemical industrial park existence increases with respondents' distance to it. 35.0% of respondents living within 700m to the chemical industrial park said they did not know there was a chemical industrial park close to their home. For those living between 700m and 1400m to the industrial park, 35.3% of them indicated no awareness of the industrial park. In comparison, almost half of those living between 1400m and 2000m (43.4%) did not know there was a chemical industrial park close to their living area.

For the second measurement of awareness, we compared the distance respondents reported (≤ 500m；>500m≤ 1km; >1m≤ 1.5km; >1.5km≤ 2km, and I don't know) and their actual distance to the chemical industrial park (≤ 700m; >700≤1400m; >1400≤2000m). As presented in Fig.5, about half of respondents indicated they did not know their distance to the chemical industrial park (≤ 700m: 47.5%; >700≤1400m: 53.3%; >1400≤2000m: 56%). It also indicates that the further respondents were away from the chemical industrial park, the more likely they could not estimate their distance to it. Fig. 3 also shows that respondents tended to overestimate their distance to the industrial park. For those living within 700m to the industrial park, at least 34.0% of them reported that their home was more than 1km away from the industrial park. For those living between 700m and 1400m, 28.7% of them said they were living

1.5km away from the industrial park. Only 17.8% of those living between 1400m and 2000m could correctly report their distance to the industrial park.

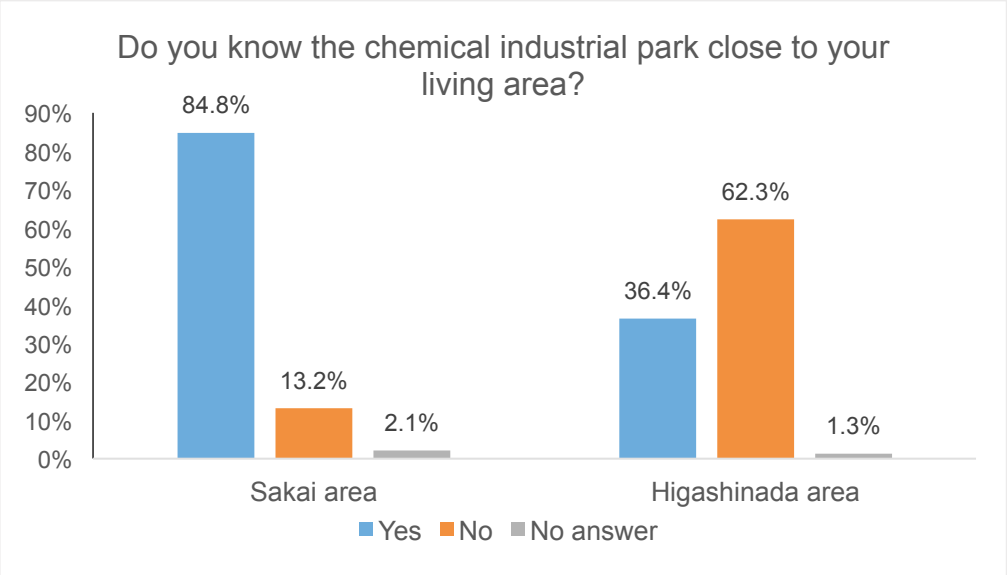

Fig. 3 Respondents' awareness of the existence of chemical industrial park.

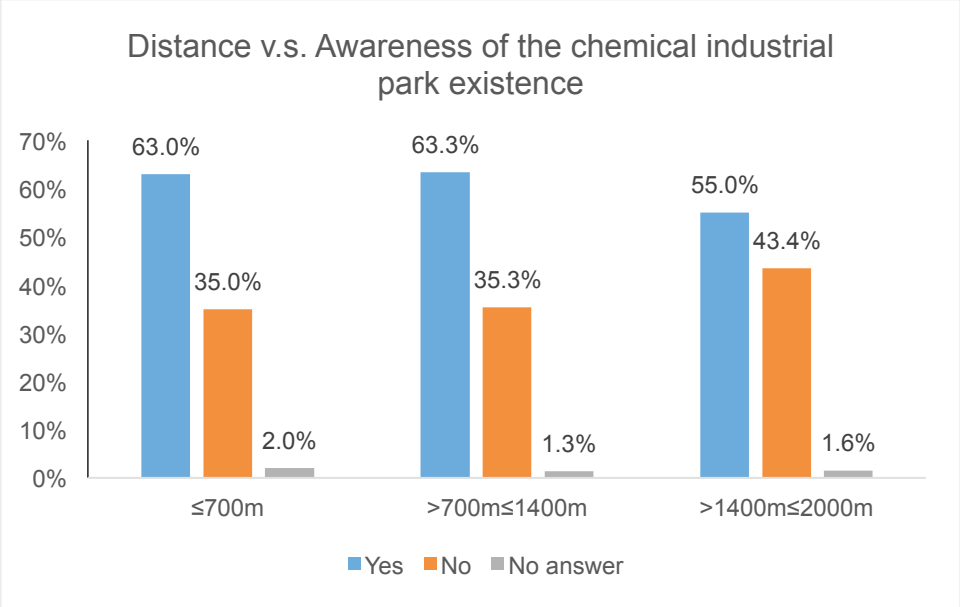

Fig. 4 Respondents' distance and their awareness of the existence of the chemical industrial park

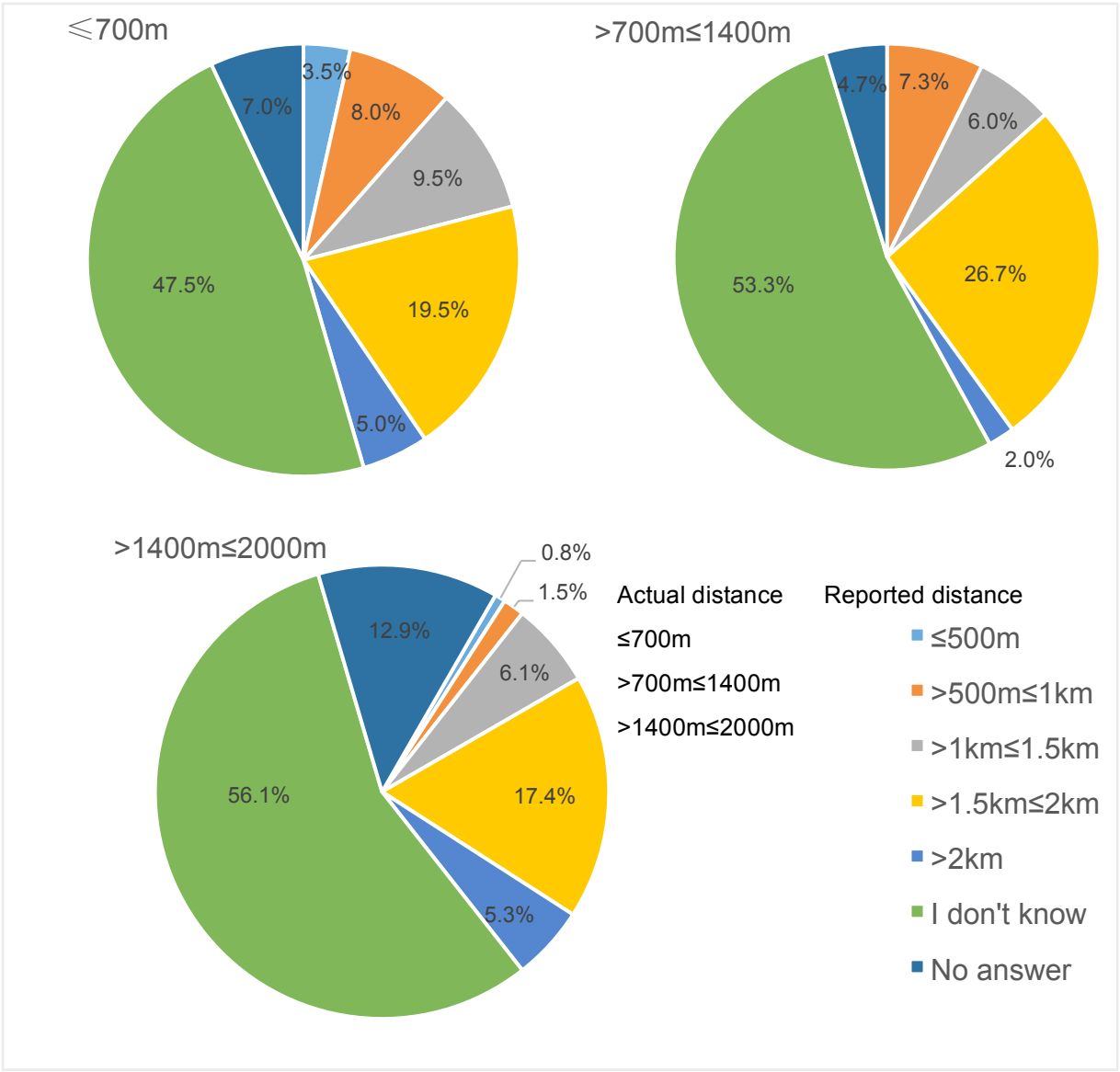

Fig. 5 Actual and reported distance to the chemical industrial park

4. 4 Risk perception

We used likelihood and severity to measure the risk perception levels by asking: how likely do you think that an earthquake, tsunami, chemical, or Natech accident may occur in/ close to your community in the next 10 years: 1(= very unlikely), 2(= somewhat unlikely),3(= somewhat likely),4(= likely),5(= very likely), and "I don't know". Furthermore, we asked to what extent households felt the earthquake, tsunami, chemical and Natech accident would affect their lives or property: 1(= not at all), 2(= to a small extent), 3(= to some extent), 4(= to a great extent), and "I don't know".

As shown in Fig. 6, respondents in Sakai area perceived higher likelihood of the occurrence of an earthquake (M=3.87±0.93 vs. M=3.54±1.01), tsunami (M=3.36±1.07 vs. M=2.88±1.25), chemical accident (M=3.33±1.13 vs. M=2.47±1.27), and Natech accident

(M=3.67±1.07 vs. M=2.85±1.24) than those in Higashinada area. The results of a t-test indicate that all the differences are significant. In both areas, earthquake was considered as the hazard that was most likely to occur in/close to the respondents' community in the next 10 years, while the chemical accident was the least likely event to occur.

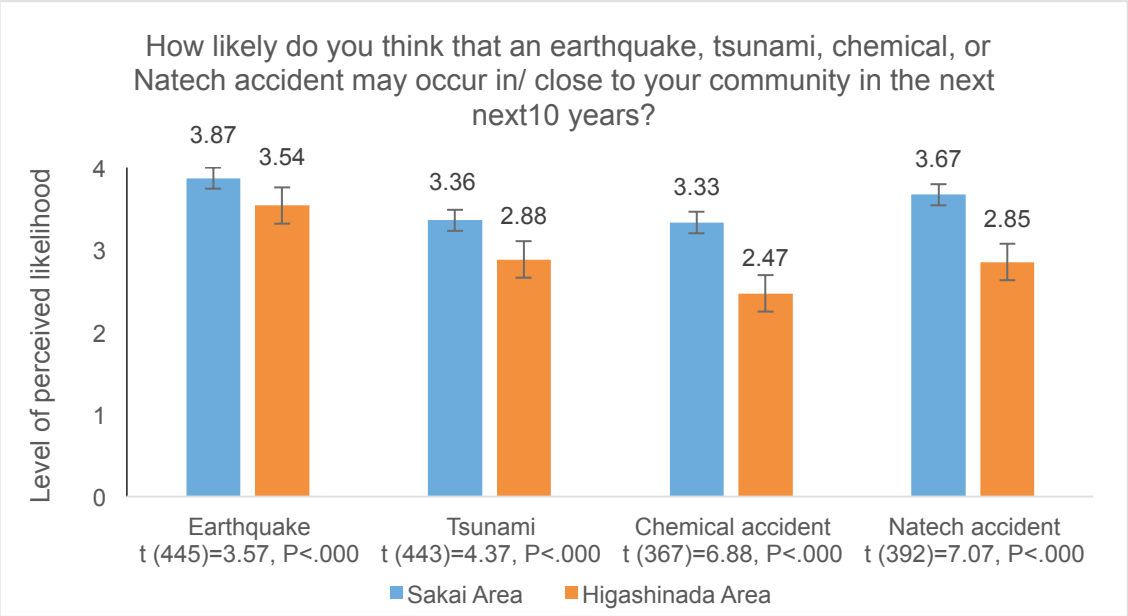

Fig. 6 Mean risk likelihood rating for earthquake, tsunami, chemical accident, and Natech accident in Sakai and Higashinada area

※Note: for those indicated "I don't know" were not counted in calculating the mean value of risk perception levels. This note is also applicable for Fig. 7, Fig. 10, and Fig. 11.

As indicated in Fig. 7, respondents in the Sakai area perceived significantly higher severity of being affected by the tsunami (M=3.18±0.87 vs. M=2.53±1.00, t (431)=7.31, p<.000), chemical accident (M=3.00±0.89 vs. M=2.24±1.01, t(355)=7.45, p<.000) and Natech accident (M=3.10±0.83 vs. M=2.31±0.95, t(388)=8.86, p<.000) than those in the Higashinada area. Even though the result was not significant based on the independent samples t-test, respondents in Sakai area did perceive a higher risk in terms of severity resulting from an earthquake impact than those in the Higashinada area (M=3.40±0.68 vs. M=3.34±0.76, t(440)=0.95, p=0.34). Similarly, respondents in both Sakai and Higashinada areas felt an earthquake would affect their lives or property most severely, while the chemical accident would cause the less severe impacts.

The results above indicate that respondents in the Higashinada area perceived lower likelihood of occurrence and severity of impacts due to an earthquake, a tsunami, a chemical and a Natech accident. This may be due to the fact that a higher percentage of Higashinada area respondents could not estimate their risk levels. As indicated in Fig. 8, 32.6% of Higashinada respondents indicated that they did not know about the likelihood that a

chemical accident may occur in/close to their community in the next 10 years. Meanwhile, 30.1%, 22.5%, and 22.9% of Higashinada respondents indicated that they did not know how severe the impacts on their lives or property caused by a tsunami, chemical and Natech accident, respectively, would be (see Fig. 9).

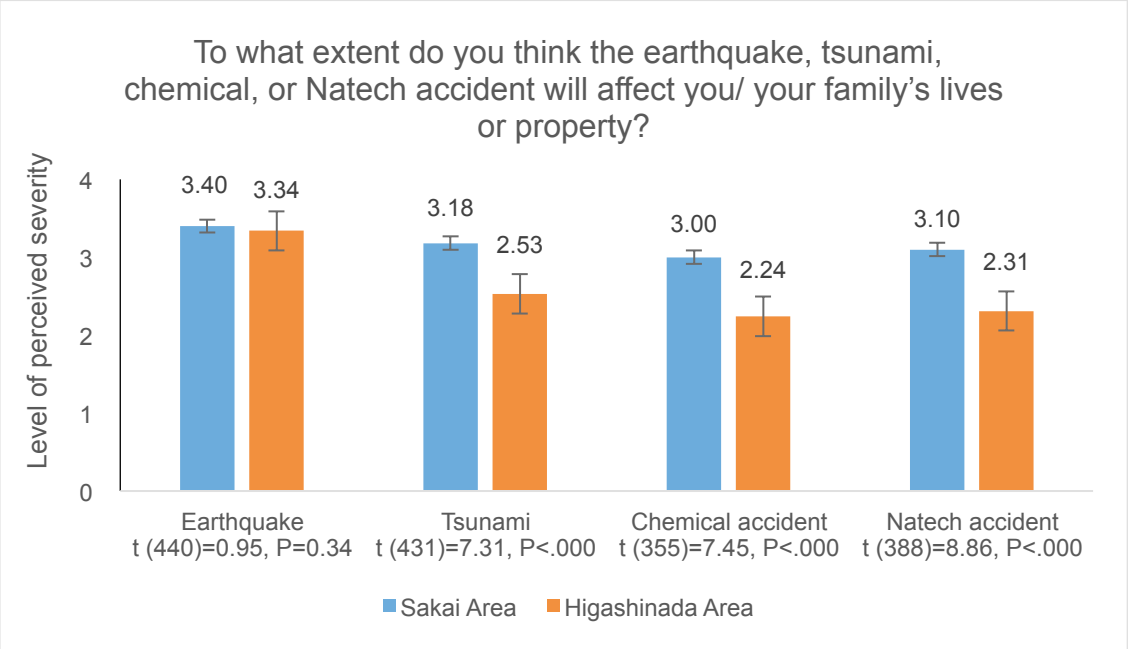

Fig. 7 Mean risk severity rating for earthquake, tsunami, chemical accident, and Natech accident in Sakai and Higashinada area

Fig. 10 and Fig. 11 present the mean perceived likelihood and severity (earthquake, tsunami, chemical and Natech accident) according to respondents' distance to the chemical industrial park (≤700m; >700m≤1400m; >1400m≤2000m), respectively. The results show that respondents' perceived risk level in terms of likelihood and severity decreased with respondents' distance to the chemical industrial park. Notably, respondents' perceived likelihood that a tsunami may occur close/in their community was significantly different according to their distance ($F(2,442) = 9.58$, $p<.000$). Furthermore, respondents' perceived severity that a tsunami ($F(2,430) = 14.38$, $p<.000$), chemical ($F(2,354) = 3.89$, $p=0.02$) and Natech accident ($F(2,387) = 3.46$, $p=0.03$) would affect their lives or property were also significantly different according to the distance.

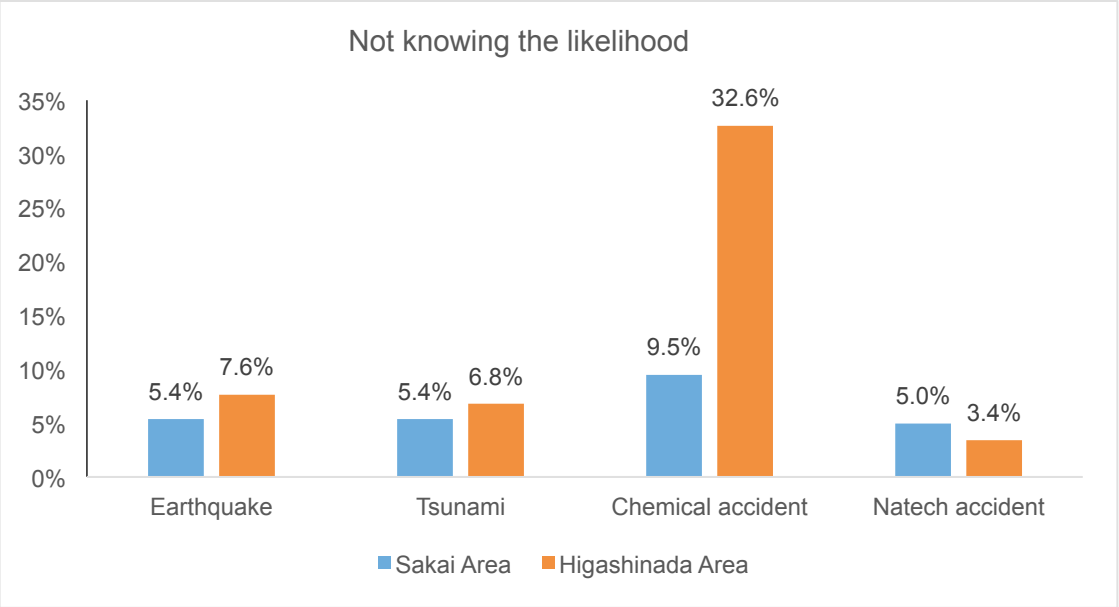

Fig. 8 The percentage of respondents who indicated that they did not know the likelihood of an earthquake, tsunami, chemical accident, and Natech accident in Sakai and Higashinada area

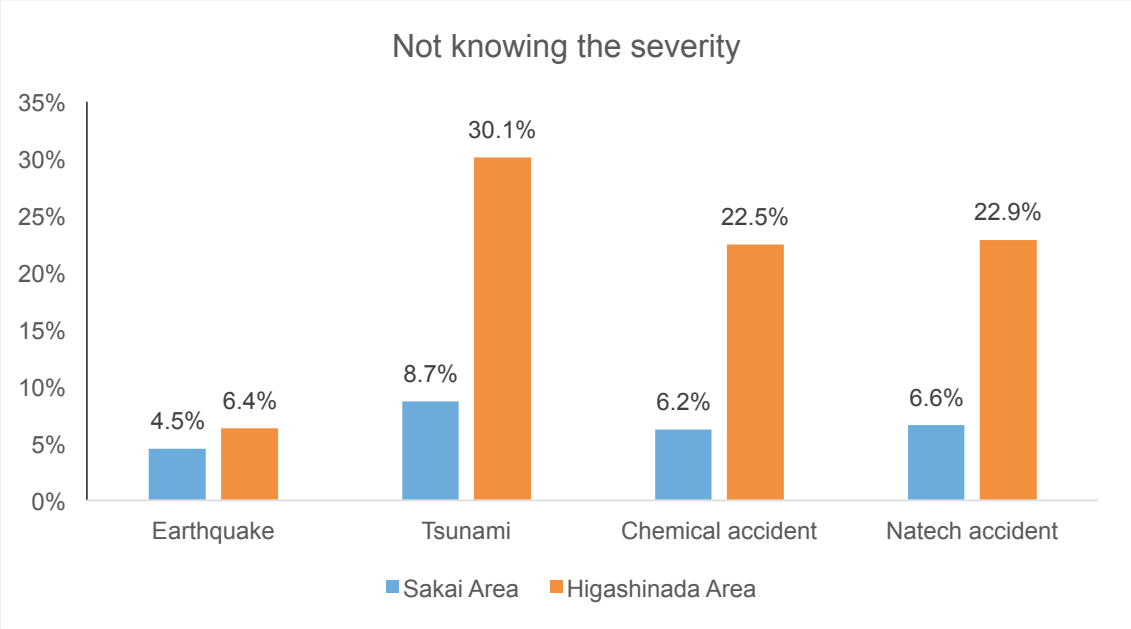

Fig. 9 The percentage of respondents that indicated that they did not know how severe the impacts of the earthquake, tsunami, chemical accident, and Natech accident in Sakai and Higashinada area would be.

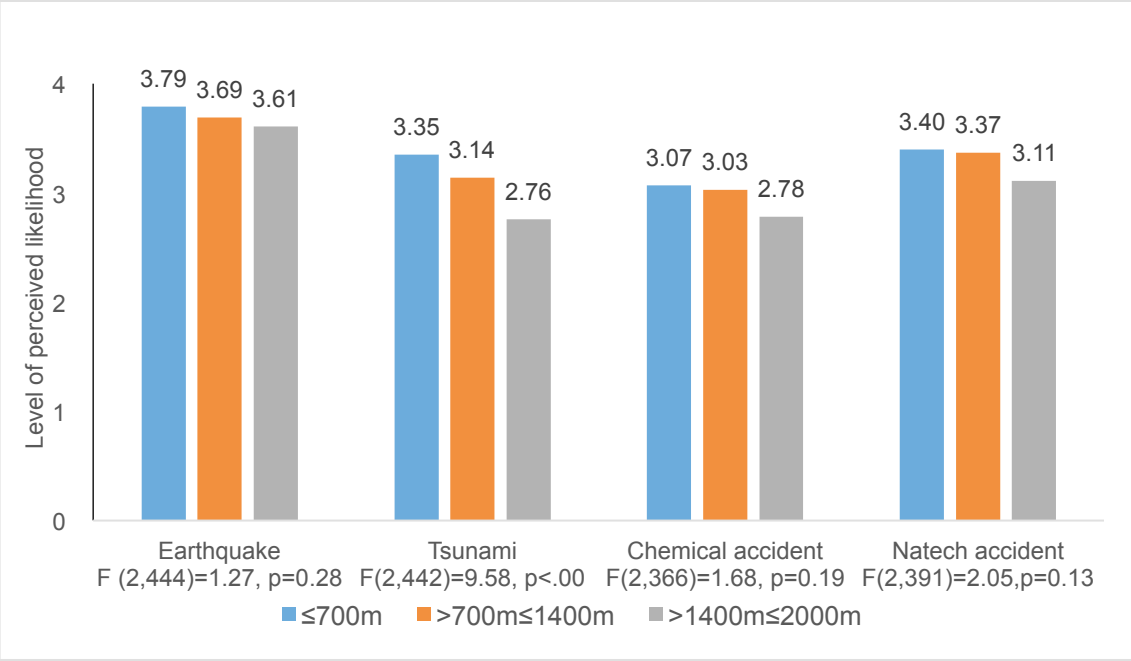

Fig.10 Mean perceived earthquake, tsunami, chemical and Natech accident likelihood by distance

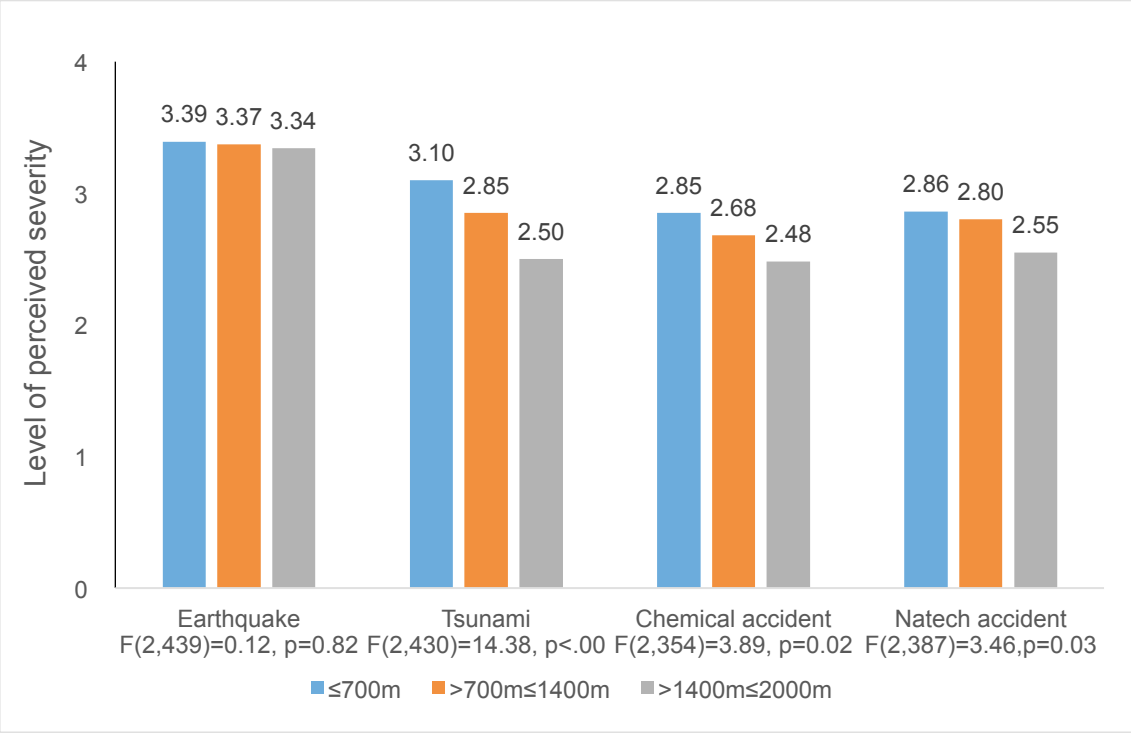

Fig.11 Mean perceived earthquake, tsunami, chemical and Natech accident severity by distance

We examined the correlations between the risk perception and demographic variables. As shown in Table 4, respondents' gender, income and whether having someone living in

respondents' houses working for an industrial firm handling hazardous materials were not significantly correlated with risk perception. However, age, household size, whether having children in the house, house ownership, and residency length were found to be correlated with risk perception. Specifically, the older were less likely to think that an earthquake (r = -0.11), tsunami (r = -0.13), and Natech accident (r = -0.14) would occur close/in their living area in the next 10 years. Furthermore, the older were also less likely to consider that an earthquake (r = -0.10), tsunami (r = -0.19) and Natech (r = -0.13) would affect their lives or property to a great extent. In comparison, larger families tended to feel that an earthquake (r = 0.15), tsunami (r = 0.11) and Natech accident (r = 0.12) would affect their lives or property to a great extent.

Table 4. Correlations between risk perception and demographic variables

	L_EQ	L_Tsu	L_Che	L_Nat	S_EQ	S_Tsu	S_Che	S_Nat
Gender	.07	.06	-.01	-.03	.08	.05	.07	.05
Age	**-.11***	**-.13****	-.07	**-.14****	**-.10***	**-.19****	-.10	**-.13***
HHsize	.09	.07	.11	.09	**.15****	**.11***	.13*	**.12***
Children	.09	**.11***	.04	**.12***	-.01	.08	.12*	**.11***
W_HC	.07	.10	.02	.08	.07	.06	.03	.02
H_own	.07	.01	.07	**.16****	**.12***	.08	**.18****	**.15****
R_Length	.01	-.03	.07	**.11***	**.13****	.05	**.19****	**.15****
Income	.07	-.02	.06	.01	.04	.01	-.01	.02

**. Correlation is significant at the 0.01 level (2-tailed).

*. Correlation is significant at the 0.05 level (2-tailed).

L_EQ: perceived likelihood of earthquake; L_Tsu: perceived likelihood of tsunami

L_Che: perceived likelihood of chemical accident; L_Nat: perceived likelihood of Natech accident

S_EQ: perceived severity of earthquake; S_Tsu: perceived severity of tsunami;

S_Che: perceived severity of chemical accident; S_Nat: perceived severity of Natech accident

HHsize: household size; Children: have (not)children at the current house

W_HC: have (not) a family member working the company handling hazardous materials

H_own: house ownership; R_Length: residency length

Responders that indicated they were families with children were more likely to respond that a tsunami (r =0.11) or a Natech accident (r = 0.12) would occur close/ in their living area in the next 10 years. They also tended to think the Natech accident would affect their lives/property to a great extent (r = 0.12). House owners and long-term residents were more likely to have higher risk perception levels in terms of perceived Natech likelihood (r = 0.16, r = 0.11). Moreover, they were also more likely to think that the earthquake (r = 0.13), chemical accident (r = 0.19)

and Natech accident (r = 0.15) would affect their lives/property to a great extent.

4. 5 Acceptance

Companies at the industrial park do everything to ensure the safety of their operations. However, there is always a small chance that a large accident can happen. In order to measure households' acceptance level of such situation, we asked them to indicate whether it is 1= completely unacceptable; 2 = somewhat unacceptable; 3 = unacceptable; 4 = somewhat acceptable; 5 = completely acceptable; or 6=uncerta.

The results show that on average, respondents in the Sakai area (M = 2.35) were more likely to accept the situation described above than those in the Higashinada area (M = 2.22). As indicated in Fig. 12, in the Sakai area, those living more than 700m (M = 2.38) away from the industrial park had higher acceptance levels than those within 700m (M=2.29). In the Higashinada area, those living beyond 1400m (M = 2.27) were more likely to respond that that it was acceptable that a large accident might occur at the industrial park than those living between 700m and 1.4km (M = 2.22), and within 700m (M=2.19). Fig.13 shows that those in the Sakai area reporting living more than 2km away from the industrial park had the highest acceptance level (M = 2.60). Meanwhile, those in the Higashinada area who reported living between 1.5 and 2km away from the industrial park had the highest acceptance level (M = 2.35). In addition, 16.2% and 21.9% of respondents in the Sakai and Higashinada areas were uncertain about their acceptance to the large accident occurring at the industrial park, respectively.

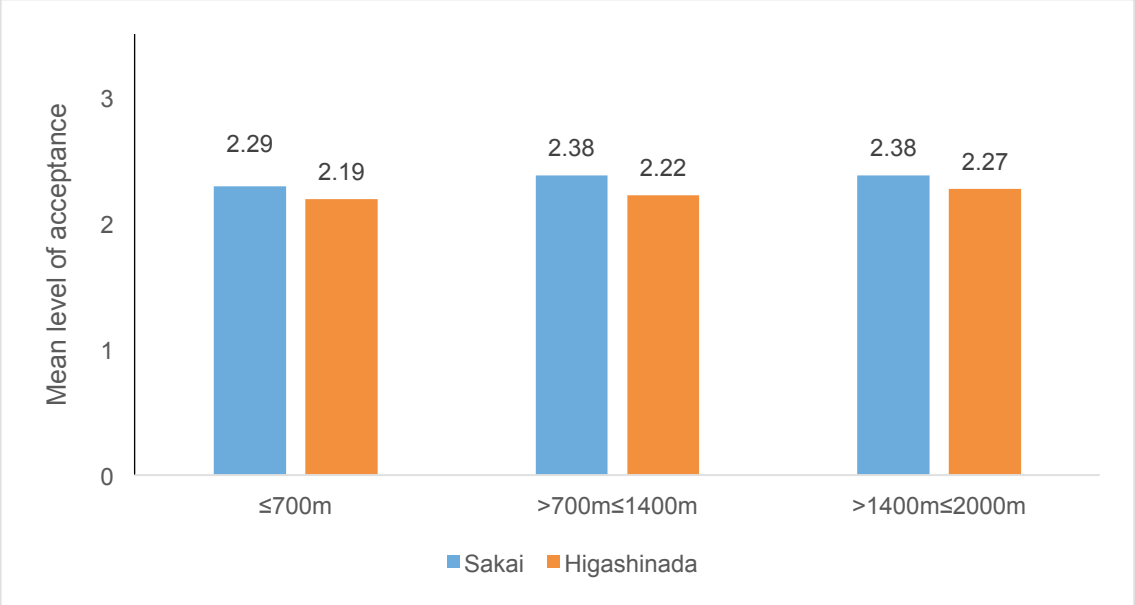

Fig. 12 Mean risk acceptance level of respondents in Sakai and Higashinada area by actual distance

※Note: for those indicated "Uncertain" were not counted in calculating the mean value of risk acceptance levels. This note is also applicable for 13.

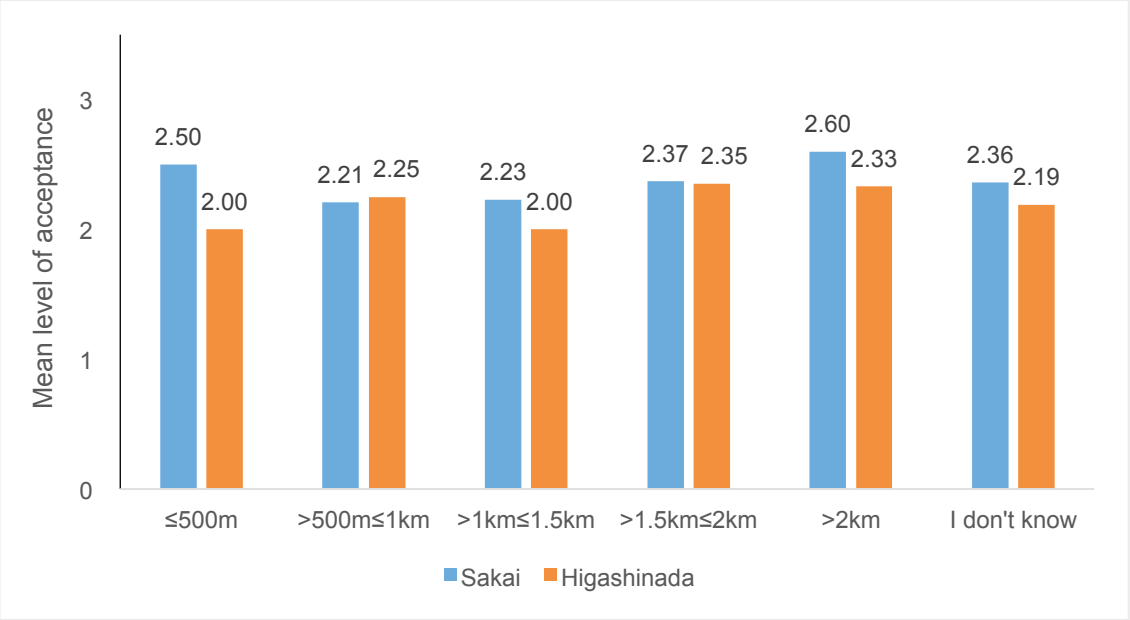

Fig. 13 Mean risk acceptance level of respondents in Sakai and Higashinada area by reported distance

4. 6 Mitigation measures

Respondents were asked to indicate the measures they had adopted and planned to adopt for mitigating the damage from earthquake, tsunami, and chemical accident. Table 5 lists the results. It shows that, in both Sakai and Higashinada areas, respondents adopted more "soft" measures than "hard" measures. About 36.4%-56.0% of respondents in Sakai and Higashinada areas had adopted "soft" measures such as buying disaster insurance (37.0% and 39.8%, respectively); making an emergency communication plan (44.4% and 44.1%, respectively); planning the emergency meeting places (48.1% and 42.4%, respectively); planning the evacuation route (46.9% and 36.4%, respectively); and learning the location of nearby evacuation and medical centers (56.0% and 51.7%, respectively).

Except taking measures to prevent heavy objects from falling (37.9% and 52.5%, respectively), the percentage of respondents adopting other "hard" measures was less than 35%. Fortunately, a relatively large percentage of respondents indicated they would plan to adopt more "hard" measures in the future. These measures include nailing heavy furniture and appliances to walls (52.7% and 47.5%, respectively); reinforcing the dwelling (71.6% and 57.2%, respectively); raising the dwelling according to the height of last inundation (84.4% and 83.5%, respectively); constructing floodwalls or other flood or tsunami protection measures (82.3% and 80.9%, respectively); and improving the air tightness of doors and windows (76.1% and 79.7%, respectively). Only 29.2% of respondents in Sakai area and 16.5% of those in Higashinada area had attended meetings or evacuation drills on earthquake, tsunami, or chemical accident emergency preparedness. However, 51.0% and 60.6% of them planned to do so in the future, respectively.

4. 7 Hazard preparation

Table 6 lists respondents' preparedness items for the earthquake, tsunami and chemical accident. It shows that in both Sakai and Higashinada area, the preparedness levels were relatively high. More than 50% of respondents have prepared the first 8 items listed in Table 6. However, the number of respondents who indicated they kept a barbecue grill, hibachi, or camp stove to cook outdoors, or masking tape to seal off doors and windows in case of a toxic hazardous materials release was relatively low.

4. 8 Hazard Information

We asked respondents to tell us what information they would like to receive when a chemical or Natech accident happens, and how important it is for them. The importance level was measured on a scale of 1- 4 where: 1=not important at all; 2= not important; 3=important; 4=very important. Table 7 presents the respondents replies concerning their preferred information and the mean importance level of each type of information rated by the respondents in Sakai and Higashinada areas. It shows that information about the location of safe places to shelter in when a chemical or Natech accident happens was very important for the respondents in the Sakai area (M= 3.49). Information about the dangerous substances and their possible adverse effects from a chemical or Natech accident, and the safe places to shelter in were very important for Higashinada respondents (M= 3.46). There was no significant difference concerning the level of information importance between respondents in Sakai and Higashinada areas based on the t-test. Some respondents listed other information they wanted to receive. The information includes the estimated duration of being affected; the way of disseminating warning messages; and the location of safe evacuation shelter, among others.

4. 9 Trust

We asked respondents to indicate to what degree they had trust in the government's ability to protect them under the risk of an earthquake, tsunami, chemical and Natech accident: 1= do not trust at all; 2= do not trust; 3= somewhat trust; 4=completely trust; and 5=no opinion.

As indicated in Fig. 14, a relatively higher percent of respondents in the Higashinada area had no opinion on government's ability to protect them under the impact of chemical accident (22.9%) and Natech accident (22.5%). This may be due to the fact that very few respondents in the Higashinada area had experienced or attended workshops/training courses concerning chemical and Natech accidents (see Table 3). For those who provided ratings on the level of trust, the results are shown in Fig.15. It shows that on average, respondents in Higashinada area had higher trust levels in government's ability to protect them under the risk of earthquake, tsunami, chemical and Natech accident than those in the Sakai area. In both areas, the trust values in government's ability to protect them under the impact by earthquake (M = 2.46, M = 2.65, respectively), and tsunami (M = 2.47, M =2.57, respectively) were higher than for a chemical accident (M = 2.15, M =2.22, respectively) and Natech accident (M = 2.11, M =2.21, respectively).

Table 5. Measures respondents adopted and plan to adopt for mitigating the damage from earthquake, tsunami, and chemical accident

	Sakai Area (N= 243)				Higashinada Area (N=236)			
	Now	Plan to do it later	No	No answer	Now	Plan to do it later	Now	No answer
1) Nail heavy furniture and appliances to walls	27.2%	52.7%	13.2%	7.0%	34.3%	47.5%	7.6%	10.6%
2) Take measures to prevent heavy objects from falling. Such as Install latches or other devices to prevent cupboards from shaking open	37.9%	35.8%	18.5%	7.8%	52.5%	30.1%	11.4%	5.9%
3) Reinforce your dwelling	14.0%	71.6%	8.6%	5.8%	28.8%	57.2%	3.8%	10.2%
4) Raise your dwelling according to the height of last inundation	5.8%	84.4%	2.5%	7.4%	2.5%	83.5%	2.1%	11.9%
5) Construct floodwalls or other flood or tsunami protection measures	2.5%	82.3%	4.5%	10.7%	1.3%	80.9%	1.3%	16.5%
6) Improve the air tightness of doors and windows	9.1%	76.1%	7.4%	7.4%	5.5%	79.7%	1.3%	13.6%
7) Buy disaster insurance	37.0%	46.9%	7.8%	8.2%	39.8%	49.2%	3.0%	8.1%
8) Make the emergency communication plan	44.4%	25.1%	25.1%	5.3%	44.1%	29.2%	19.1%	7.6%
9) Plan the emergency meeting places	48.1%	23.9%	23.5%	4.5%	42.4%	30.5%	20.3%	6.8%
10) Plan your evacuation route	46.9%	28.8%	17.3%	7.0%	36.4%	39.4%	15.3%	8.9%
11) Learn the location of nearby evacuation and medical centers	56.0%	20.2%	18.5%	5.3%	51.7%	26.3%	16.1%	5.9%
12) Attend meetings or evacuation drill on earthquake, tsunami, or chemical accident emergency preparedness	29.2%	51.0%	16.0%	3.7%	16.5%	60.6%	14.8%	8.1%

※ multiple choices are possible

Table 6. Respondents' preparation for the earthquake, tsunami and chemical accident

	Sakai Area (N= 243)			Higashinada Area (N=236)		
	Yes	No	No answer	Yes	No	No answer
1) Fire extinguisher	55.6%	41.6%	2.9%	53.0%	43.2%	3.8%
2) First aid kit	78.6%	18.5%	2.5%	79.7%	18.2%	2.1%
3) Portable radio with extra batteries	85.2%	14.4%	0.4%	85.2%	13.6%	1.3%
4) Flashlight with extra batteries	93.0%	5.8%	1.2%	95.8%	3.8%	0.4%
5) At least three day supply of any medication being taken by you or a family member	54.7%	42.0%	3.3%	61.0%	36.4%	2.5%
6) At least three day supply of water for every member of your household	56.8%	37.9%	5.3%	58.9%	35.2%	5.9%
7) At least three day supply of food to feed every member of your household	56.0%	39.1%	4.9%	59.3%	34.7%	5.9%
8) At least a three day supply of waterproof, plastic bags to dispose of waste	74.1%	18.5%	7.4%	79.7%	14.8%	5.5%
9) A barbecue, hibachi, or camp stove to cook outdoors	33.7%	60.5%	5.8%	30.9%	63.1%	5.9%
10) Masking tape to seal off doors and windows in case of toxic hazardous materials release	26.7%	67.1%	6.2%	22.5%	70.8%	6.8%

※ multiple choices are possible

Table 7. Information preference and the mean importance level

	Sakai Area	Higashinada Area	T test
1) Dangerous substances and their possible adverse effects	3.46	3.46	t (445)=0.13, p=0.90
2) How to respond	3.35	3.33	t (447)=0.27, p=0.79
3) Its influencing scope	3.42	3.43	t (448)=-0.05, p=0.96
4) Safe place to shelter in	3.49	3.46	t (450)=0.52, p=0.61

The second way we measured trust was to explore households' views on the local industrial risks. We asked respondents to indicate if they 1=agree; 2= somewhat agree; 3=neither agree nor disagree; 4= somewhat disagree; 5= disagree; and "I don't know" about the statements that 1) I believe that reports by chemical plants to the government about their companies' safety records

are accurate; 2) I believe local governments are committed to insure the safety of chemical industries; 3) I believe local governments are making efforts to inform, explain, and respond to public concerns regarding the risk of chemical accidents; 4) I am concerned about health and safety threats from local industry; 5) I believe local industry tries very hard to reduce the chance of chemical accidents; 6) I believe local industry has publicized what it is doing to reduce the chance of chemical accidents.

As indicated in Table 7 and Table 8, respondents in Sakai and Higashinada areas had similar views concerning the local industrial risks. For the first statement "I believe that reports by chemical plant to the government about their companies' safety records are accurate", 24.7% of respondents in Sakai area and 24.2% of those in Higashinada area indicated that "I don't know". 20.2% and 20.8% of respondents in Sakai and Higashinada areas, respectively disagreed with the statement that "I believe local governments are committed to insure the safety of chemical industries". Similarly, the percentage of "disagree" on "I believe local governments are making efforts to inform, explain, and respond to public concerns regarding the risk of chemical accidents" was also relatively high (30.0% in Sakai area, and 27.5% in Higashinada area). In both areas, respondents show their high concerns on the "health and safety threats from the local industry" (29.6% in Sakai area, 20.3% in Higashinada area). For the last two statements: "I believe local industry tries very hard to reduce the likelihood of chemical accidents" and "I believe local industry has publicized what it is doing to reduce the likelihood of chemical accidents", a higher percentage of respondents said they could not give an answer.

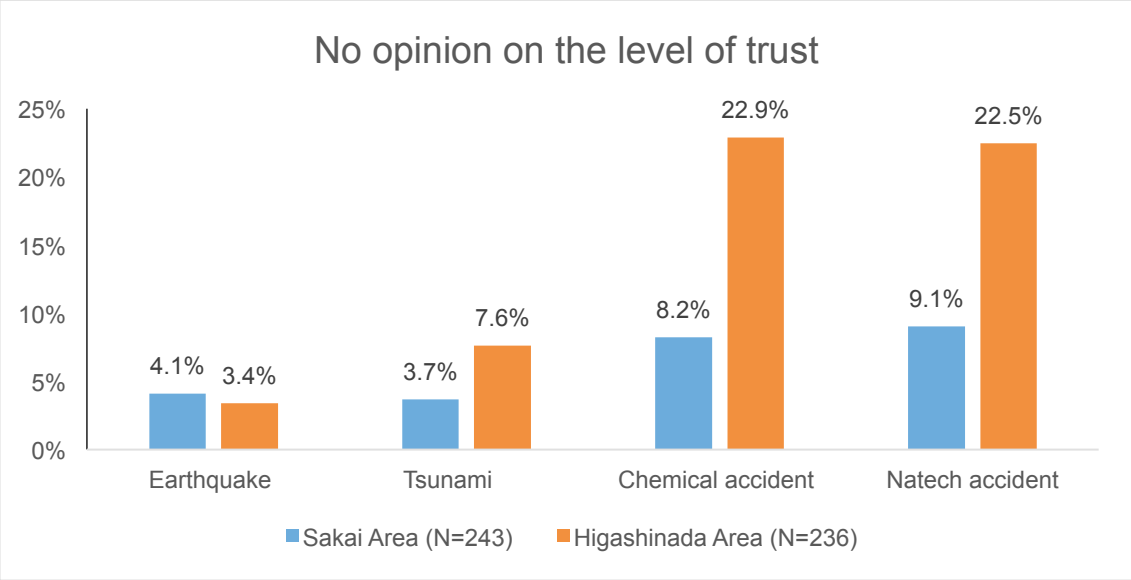

Fig. 14 The percentage of respondents could not tell the level of trust in the government's ability to protect them under the risk of earthquake, tsunami, chemical and Natech accident

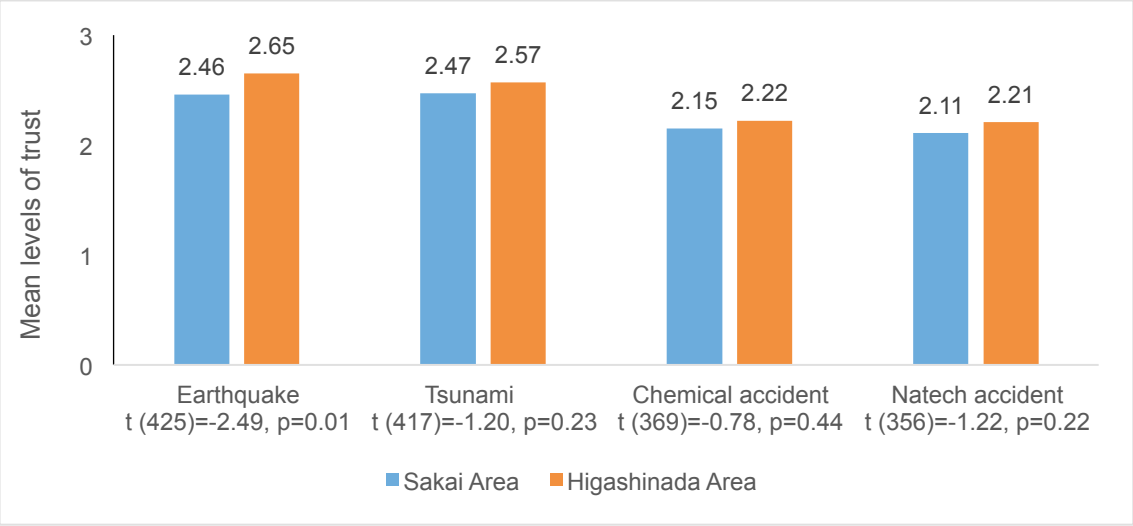

Fig. 15 Mean level of trust in government's ability to protect respondents under the risk of an earthquake, tsunami, chemical and Natech accident

※Note: for those indicated "No opinion" were not counted in calculating the mean value of trust.

Table 7. Views of local industrial risks (Sakai area)

Sakai Area	Mean	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	disagree	I don't know	No answer
1) I believe that reports by chemical plant to the government about their companies' safety records are accurate	3.13	7.4%	16.5%	14.0%	9.5%	14.8%	24.7%	13.2%
2) I believe local governments are committed to insure the safety of chemical industries	3.46	4.9%	14.4%	13.2%	14.8%	20.2%	21.4%	11.1%
3) I believe local governments are making efforts to inform, explain, and response to public concerns regarding the risk of chemical accidents	3.90	1.6%	9.5%	13.6%	16.0%	30.0%	18.1%	11.1%
4) I am concerned about health and safety threats from local industry	2.19	29.6%	23.5%	9.5%	8.2%	6.2%	12.8%	10.3%
5) I believe Local industry tries very hard to reduce the chance of chemical accidents	2.59	11.1%	22.6%	13.2%	8.2%	5.8%	28.0%	11.1%
6) I believe Local industry has publicized what it is doing to reduce the chance of chemical accidents	3.77	2.9%	7.8%	9.1%	7.8%	21.8%	39.5%	11.1%

Table 8. Views of local industrial risks (Higashinada area)

Higashinada Area	Mean	Agree	Somewhat agree	Neither agree nor disagree	Somewhat disagree	disagree	I don't know	No answer
1) I believe that reports by chemical plant to the government about their companies' safety records are accurate	3.25	4.2%	14.0%	17.4%	11.9%	12.7%	24.2%	15.7%
2) I believe local governments are committed to insure the safety of chemical industries	3.63	2.1%	10.6%	15.7%	11.0%	20.8%	25.8%	14.0%
3) I believe local governments are making efforts to inform, explain, and response to public concerns regarding the risk of chemical accidents	4.08	0.4%	4.7%	12.3%	14.0%	27.5%	26.3%	14.8%
4) I am concerned about health and safety threats from local industry	2.28	20.3%	19.5%	12.7%	6.4%	4.2%	22.9%	14.0%
5) I believe Local industry tries very hard to reduce the chance of chemical accidents	3.10	3.4%	15.3%	14.0%	4.7%	11.0%	37.7%	14.0%
6) I believe Local industry has publicized what it is doing to reduce the chance of chemical accidents	3.99	2.3%	5.4%	9.4%	7.5%	21.1%	40.7%	13.6%

5. Summary and Conclusion

This research project collected data from two communities in Sakai (Osaka, Japan) and Higashinada (Kobe, Japan), focusing on household awareness, risk perception and hazard adjustments for the earthquake, tsunami, chemical and Natech accidents. Furthermore, we also examined household views (acceptance, trust, and information needed) towards local government and industries' ability to protect them under the risk of earthquake, tsunami, chemical and Natech accidents. Considering the seven research objectives stated in section 1, we found:

1. Most households in Sakai and Higshinada areas had experienced an earthquake, but few of them had experienced a tsunami or a chemical accident. However, 37.5% of respondents in Sakai area had seen the fire or smelt the smoke from the industrial area often or occasionally. In comparison, respondents in the Higashinada area rarely observed the dangerous environmental cues from the industrial park. Even though many of respondents in the two surveyed areas had attended the workshop/training courses for the earthquake or tsunami, few of them did so for the chemical or Natech accidents

2. Many more households from the Sakai area knew about the existence of the industrial park close to their living area than those from the Higashinada area. This may be because more than one third of the households from the Sakai area had seen the fire or smelt the smoke from the industrial area often or occasionally. In addition, the percentage of respondents not knowing about the existence of an industrial park close to their community increased with the distance to the industrial park. Moreover, we found about half of the respondents could not estimate their distance to the industrial park, and the further respondents were from the industrial park, the more likely they could not estimate their distance to it.

3. Households in Sakai and Higashinada areas perceived significantly different risks from earthquakes, tsunami, chemical and Natech accidents. We found that households in the Sakai area were more likely to think an earthquake, tsunami, chemical or Natech accident would occur close to their living area within 10 years than those in the Higashinada area. Households in the Sakai area were also more likely to think they would be affected by the tsunami, chemical and Natech accidents to a great extent. In both areas, an earthquake was regarded as the most likely event to occur and most devastating hazard for their lives or property. In comparison, the chemical accident was considered as the least likely to occur and least devastating hazard.

Risk perception levels were found to be associated with distance, age, household size, whether there were children in the current house, house ownership, and the residency length. Specifically, those living close to the industrial park tended to think an earthquake (not significant); tsunami (significant), chemical accident (not significant), and Natech accident (not significant) would occur close to/in their living area in the next 10 years. Furthermore,

those living close to the industrial park also tended to think the that the tsunami, chemical accident, and Natech accident would significantly affect their lives or property to a great extent. Furthermore, older people were significantly less likely to perceive a higher risk in terms of likelihood and severity for earthquake, tsunami and Natech accident. In comparison, the families with more members perceived significant higher risk in terms of severity in earthquake, tsunami, and Natech accident. Another group that also had higher risk perception levels were the families with children. They were significantly more likely to perceive a higher risk in terms of likelihood for earthquake and Natech accident, and of severity for the Natech accident. House owners and those long-term residents were significantly more likely to have higher risk perception levels in terms of perceived Natech likelihood. Moreover, they were also more likely to significantly think that the earthquake, chemical accident and Natech accident would affect their lives/property to a great extent.

4. On average, respondents in Sakai area were more accepting of the possibility that a large accident could occur in the industrial park than those in the Higashinada area. Furthermore, those living further away from the industrial park also had higher acceptance levels.

5. In both Sakai and Higashinada areas, respondents adopted more "soft" hazard mitigation measures (buying disaster insurance, making a emergency communication plan, etc.) than "hard" measures (reinforcing the dwelling, raising the dwelling, etc.). Fortunately, a relatively large percent of respondents indicated they would plan to adopt more "hard" measures later. The level of preparedness in both Sakai and Higashinada areas were relatively high. However, few respondents had masking tape to seal off doors and windows in case of a chemical or Natech accident involving toxic material releases.

6. There was no significant difference between the Sakai and Higashinada areas concerning the preference for the kind of information respondents would like to receive when a chemical or Natech accident happens. Residents indicated that knowing about the safe place to shelter in and the dangerous substance(s) released and their possible adverse effects were the most important information.

7. Households in Higashinada area had higher trust levels in government's ability to protect them under the risk of earthquake, tsunami, chemical and Natech accidents than those in the Sakai area. Households in both areas were more confident in government's ability under the impact of an earthquake and a tsunami than by the chemical and Natech accident. There was no significant difference concerning the views of industrial risk between the Sakai and Higashinada area. However, the relatively high percentage of respondents that had no opinion on the industrial risks indicates that many people are not familiar with such risks.

One significance of this project is that it contributes to our understanding of household preparedness for the natural, chemical and Natech

hazard threats. Our findings show that in both surveyed areas, households had prepared well for the natural hazards such as earthquake and tsunami, but not well for the chemical and Natech accidents. This may be due to the fact that more than half of respondents answered that "No such activities" are carried out in their communities regarding chemical or Natech accidents.

Households may start to prepare for chemical or Natech accidents after this survey. This is evidenced by the fact that a large percentage of respondents indicated that they were planning to adopt preparedness measure for chemical accidents such as improving the air tightness of doors and windows.. Nevertheless, the low preparedness levels suggest that more needs to be done. Local authorities, industries and other organizations should carry out more activities such as workshops, training, making TV or radio programs, or sending pamphlets, etc. to increase household familiarity with threats posed by chemical and Natech accidents, and the prevention and preparedness measures they can take to protect their lives and property.

This study found that households from in both areas surveyed had lower risk perception (in terms of likelihood and severity) concerning the threats posed by chemical and Natech accidents. This is bad news for the local government because protective behavior during these types of accidents has been found to be positively correlated with risk perception (Yu, Cruz and Hokugo 2016). Low risk perception may mean that households may not take protective actions when needed in such emergency situations. Thus, measures should be adopted to increase household risk perceptions for chemical and Natech accidents.

This study found that households level of trust in government's ability to protect them under the risk of chemical and Natech accidents was low. On the other hand, although households in both areas surveyed perceived high risk of being affected by an earthquake and a tsunami, they had more trust in local government's ability to protect them under such risks.

This study has provided insights concerning current preparedness levels of households located near industrial parks at risk from chemical accidents during large earthquakes and tsunami clearly indicating the need to provide better information to residents living near industrial parks regarding the risks they are subject to and they types of protective actions they can take if an accident occurs.

Acknowledgements

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