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Paper:

Effect of the Seven Critical Elements on Life Recovery Following the Great East Japan Earthquake Disaster

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The purpose of this study is to compare the effect size of seven critical elements on the life recovery in three prefectures, Iwate Prefecture, Miyagi Prefecture, and Fukushima Prefecture, which were severely damaged by the Great East Japan Earthquake Disaster. This study used the 2016 Tohoku Life Recovery Survey (N = 2111, response rate: 35.2%) for the analysis. The dataset was divided into each prefecture sample to compare the effects of seven critical elements on life recovery in the three prefectures. We obtained samples from Fukushima (N = 603), Iwate (N = 781), and Miyagi (N = 727). First, the distribution of life recovery by the three prefectures was confirmed. The results showed that those affected by the Great East Japan Earthquake disaster in Miyagi have a higher quality of life recovery. Finally, we compared the effects of seven critical elements on life recovery among the three prefectures' models using GLM analysis. From the comparison of effect size (partial η^2) and discussion, three points are shown. 1) In the Fukushima model, the effect size of physical/mental stress management and social ties was larger than in the other models. 2) The effects of 1) were caused by the experience of diaspora (nuclear disaster-caused displacement). 3) If forced diaspora can create good relationships with local people, the positive effects of social ties on life recovery for such people are larger than for those who have not experienced diaspora.

Keywords: the Great East Japan Earthquake disaster, life recovery, subjective recovery, social survey, the Seven Critical Elements Model

1. Introduction

The Sendai Framework for Disaster Risk Reduction noted seven goals and four priorities for action in the next 15 years. Priority 4 is "Enhancing disaster preparedness for effective response and to 'Build Back Better' in recovery, rehabilitation and reconstruction" [1]. This paper aims to reveal what factors contribute to "Build Back Better" and how we can support it based on the 2016 Life Recovery Survey, which was conducted in the area affected by the Great East Japan Earthquake.

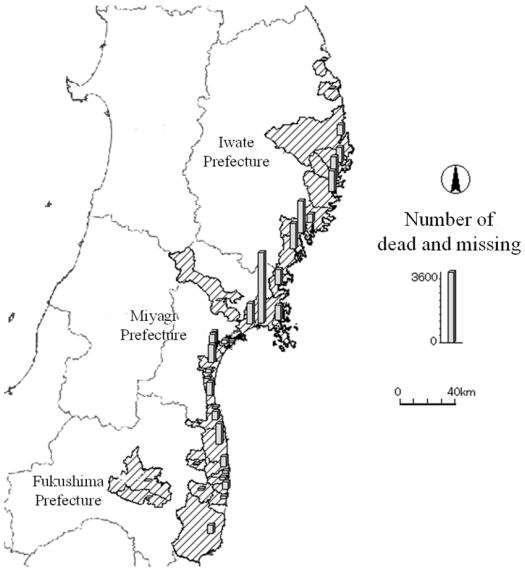

Fig. 1. Research area and the number of dead and missing.

The Great East Japan Earthquake disaster caused by the 2011 earthquake off the Pacific coast of Tohoku took the lives of 19,575 and completely destroyed 121,776 houses. **Fig. 1** shows the research area (shaded) and the number of dead and missing. The Great East Japan Earthquake disaster was also a nuclear disaster. The Fukushima Daiichi Nuclear Power Plant accident has forced many people to relocate from their hometowns. As of March 2012, when the largest number of evacuees had left Fukushima Prefecture, 62,831 people were evacuated from Fukushima

Prefecture (Fukushima Prefecture 2021 [2]). As of June 2021, six cities have been designated as part of the difficult-to-return zone [3]. Approximately 23,000 people who lived in these difficult-to-return areas before the disaster could not return to their homes.

Although seven years have passed since the Great East Japan Earthquake, many people still suffer from its aftermath. According to previous studies [4], it takes more than ten years to recover victims' lives from large-scale disasters. Therefore, continuous support is needed for them for additional years to recover their lives.

As a feature, the Great East Japan Earthquake affected broad areas and people across many municipalities. This means that there are many forms of recovery in each affected area. This study identifies the similarities and differences between areas affected by the Great East Japan Earthquake disaster in terms of which factors were relatively more important in determining life recovery. We then provide evidence for policy planning to achieve "Build Back Better."

Studies on the subjective sense of recovery have been examined since Bolin et al. [5–8]. He found that social factors determine a subjective sense of family recovery. In recent years, a growing number of studies have addressed the subjective sense of recovery, studying social capital [9, 10], race and class [11], infrastructure and social factors [12], and housing reconstruction assistance [13] as independent variables.

In Japan, studies on victims' life recovery following large-scale disasters began after the Great Hanshin-Awaji Earthquake. Tatsuki and Hayashi [14] explored which factors help affected citizens feel that "I am no longer a disaster victim" by grass-roots recovery assessment workshops with citizens. From these workshops, the seven critical elements model (SCEM) of life recovery was formed [14]. The seven facilitating elements consist of housing, social ties, community involvement, physical/mental stress management, preparedness, livelihood, and relations with the government [15, 16].

Based on a quantitative survey in 2001, Tamura et al. and Tatsuki and Hayashi demonstrated the validity of SCEM [17, 18]. Subsequently, Tatsuki et al. demonstrated SCEM on the life recovery process using structural equation modeling [19].

With regard to the Great East Japan Earthquake disaster, studies from 2012 to 2014 in Ofunato City, Kesennuma City, and Shinchi Town [20] showed that life recovery was consistently affected by municipality reconstruction, daily dietary habits, and housing. In this study, indicators of life recovery were based on subjective feelings that ranged from 0% to 100%. In another study conducted by Horigome et al. [21] and Abe [22] in Ofunato, the quality-of-life recovery scale developed in a series of Hyogo Life Recovery Surveys was used as the dependent variable. Kawawaki [23] precisely analyzed the impact of social capital on the subjective sense of recovery.

In Natori City in Miyagi Prefecture, continuous population surveys were conducted from 2014 to 2017. The studies from these surveys [24, 25] focused on the effects of temporary housing types on life recovery. Both studies also employed life recovery scales.

As reviewed above, many studies regarding life recovery were conducted after the Great East Japan Earthquake disaster. However, these studies focused on specific areas of research. Although it is important to research focused areas, a comparative study between affected areas was also needed because the broadness of the affected area was one of the features of the Great East Japan Earthquake disaster. As an exception, Tsuchiya et al. [20] compared three cities from the Iwate, Miyagi, and Fukushima Prefectures. This study identifies the similarities and differences in life recovery among three prefectures (Iwate, Miyagi, and Fukushima) that the Great East Japan Earthquake Disaster severely damaged. In particular, the primary purpose of the current study was to identify which critical elements were relatively more important in determining the subjective sense of life recovery by using random sampling survey data from 36 municipalities.

2. Methods

2.1. Respondents

In 2016, a random sample mail survey was conducted on 2000 earthquake victims who lived in three prefectures: Iwate, Miyagi, and Fukushima (in total, 6000 respondents). Based on the following four criteria, the subject municipalities from these three prefectures were sampled: 1) more than 1% mortality, 2) more than 10 % of houses completely destroyed, 3) more than 1000 dead or missing, and 4) more than 500 houses completely destroyed. As a result, 35 municipalities that met at least one criterion were sampled. In addition, Ichinoseki City, which had the most partly destroyed houses in the inland area, was also sampled because 35 municipalities in Iwate do not include inland cities.

Questionnaires were mailed from May to June 2016. Finally, 2111 responses (35.2%) were returned. These samples consisted of 781 responses in Iwate Prefecture, 727 in Miyagi Prefecture, and 603 in Fukushima Prefecture.

2.2. Instruments

Based on SCEM from Hyogo Life Recovery Surveys, the quality-of-life recovery scale, and the scales designed to measure each of the seven critical elements were used for our research.

Life recovery. The life recovery scale measures the degree to which one feels that he/she is no longer a disaster victim. The scale consists of 14 five-point Likert scale items that asked about 1) the fulfillment of daily activity, social relationships, and subjective well-being, compared to pre-earthquake days (strongly decreased to strongly increased; 7 items); 2) life satisfaction (strongly unsatisfied to strongly satisfied; 6 items); and 3) future prospects (will get better–will get worse; 1 item). This scale was developed in the 1999 Kobe survey and was

confirmed to be unidimensional and reliable (i.e., Cronbach's $\alpha > .80$ [14]). Moreover, it has been used in other life recovery studies and has reconfirmed reliability. This study employed summed scores. Missing items were supplemented with the average value of the items that were answered.

Housing. Satisfaction of housing was measured by a five-point Likert scale from satisfied to unsatisfied and "I don't know." A preliminary analysis shows that "Neither" and "I don't know" have similar effects on the quality-of-life recovery scale score. Therefore, we created "Neither or I don't know" as a new category by integrating these answers.

Social ties. As a variable of social ties, respondents were asked about changes in their relationships with their neighbors from the pre-disaster situation. This category was measured using a five-point Likert scale from "increased" to "decreased." This variable measures individual social capital.

Community involvement. Community involvement is a community outlook scale that measures the degree of neighbors' engagement in community affairs. We asked to choose from 1) Residents do not socialize with each other and live by themselves, 2) Residents do not socialize, but neighborhood representatives seem to be more or less active, 3) Residents socialize to a certain degree, and some greet each other, and 4) Residents socialize very often and participate significantly in community events. This question measures collective social capital, the importance of which was noted by Putnam [26]. This study assumed that the benefits of social ties are received by individuals, whereas the benefits of community participation are shared by community members.

Physical/mental stress management. Physical/mental stress management was measured using physical and psychological stress scales consisting of six physical and six psychological stress items. This scale was also developed in the 1999 Hyogo Life Recovery Survey and has been used in many studies. As a result of factor analysis, two factors – physical stress and mental stress – were extracted as assumed in the item setting. This study employed these factor-loading scores.

Livelihood. As a subjective household financial situation, we asked about household income, expenditures, and savings compared to the pre-disaster situation (increase, decrease, or no change). From these questions, economic and financial situations consisting of 1) getting better, 2) no change, and 3) worsening were created.

Preparedness/relation to the government. In this study, preparedness and relation to the government were represented by one variable. Respondents were asked about the desirable share of self-help, mutual help, and public help in disaster preparedness: 1) disaster prevention education for children, 2) means of confirming safety, and 3) food and water stockpiles. From these answers, we obtain the priority order of preparedness for each respondent. Dual scaling [27] was used to rank order data, and scaled scores were obtained. The weight from the dual scaling of rank order data is shown in **Fig. 2**. Self-help was loaded high for the first dimension. On the other hand, mutual help was loaded high, and public help was loaded on the second dimension. We regard the first dimension as the priority in self-help and the second dimension as the priority in mutual help vs. public help. The interaction of these two variables was also examined in the multiple regression models because the three factors, self-help, mutual help, and public help, are not independent but, rather, are related to each other and affect recovery.

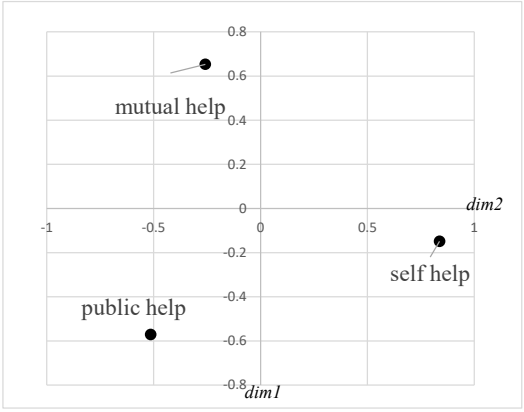

Fig. 2. Weight of preparedness/relation to government.

House damage. House damage caused by the Great East Japan Earthquake disaster was also used as an independent variable. Respondents were asked to choose from no damage, partial destruction, large-scale partial destruction, and complete destruction.

2.3. Analysis

In the following analysis, we compare the effects of seven critical elements life recovery among those who lived in three prefectures (Fukushima, Iwate, and Miyagi) when the Great East Japan Earthquake disaster occurred. Therefore, respondents were divided into three datasets based on the prefecture where they lived. Stata version 14 and SPSS version 25 were used for the statistical analysis.

3. Result

3.1. Distributions of Life Recovery

Before the move to regression analysis, a simple comparison of life recovery score among the three prefectures and the 2001 Hyogo survey was conducted. The 2001 Hyogo survey was conducted in order to reveal the life recovery processes six years after the 1995 Great Hanshin Earthquake.

Figure 3 illustrates the result of kernel density distributions of life recovery in the three prefectures and the 2001 Hyogo survey as a reference. The horizontal axis shows the life recovery scale score, and the vertical axis shows the proportion of a given score. This shows that the distribution differed between the current survey (Fukushima,

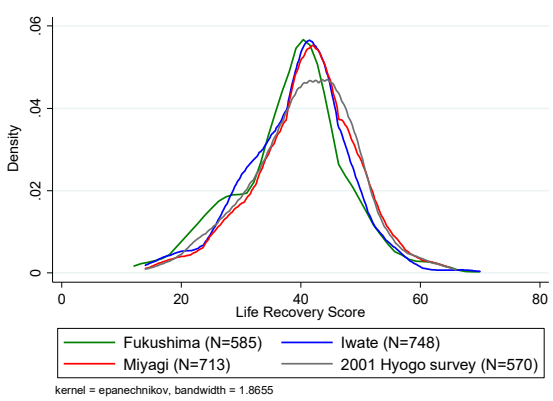

Fig. 3. Kernel density estimate of the life recovery score.

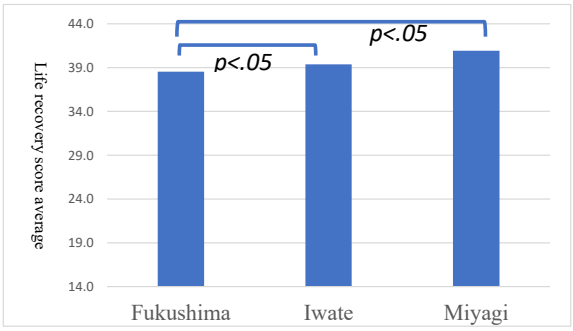

Fig. 4. The result of Tukey's test for three prefectures.

Iwate, and Miyagi) and the 2001 Hyogo survey. In contrast, there was no large difference in the shape of density among the three prefectures. With regard to the life recovery score, Miyagi seems to have higher life recovery scores than those in Fukushima and Iwate.

Figure 4 illustrate the mean life recovery score in the three samples (Fukushima, Iwate, and Miyagi). Based on the results of Tukey's test, those who lived in Miyagi Prefecture have significantly higher life recovery scores than those in Fukushima ($p < .05$) and Iwate ($p < .05$). This analysis confirmed that the life recovery differs according to the prefecture in which respondents lived before the Great East Japan Earthquake disaster. In the next section, we analyzed the difference in the effects of seven critical elements on the life recovery score among the three prefectures to identify the determinant factor of life recovery following the Great East Japan Earthquake disaster.

3.2. Effects of Seven Critical Elements on Life Recovery in the Three Prefectures

3.2.1. Model Fit

Table 1 summarizes the results of the multiple regression (GLM) analysis. It compares the effects of the seven critical elements among the three prefectures. First, we focused on model fit. The Fukushima model predicted the highest, 53.8% of the total variance in the observed life recovery score ($R^2 = .538$, adjusted $R^2 = .513$), compared to the Iwate ($R^2 = .340$, adjusted $R^2 = .311$) and Miyagi ($R^2 = .370$, adjusted $R^2 = .343$) samples.

3.2.2. Parameter Effects on Life Recovery

In this section, we introduce parameter effects, as shown in **Table 1**.

Housing. High housing satisfaction significantly promoted better recovery in each model ($p < .01$). In terms of the coefficient, 1.683 for the Miyagi sample was the highest among the three models.

Social ties. In the Fukushima and Miyagi samples, changes in relationships significantly affected life recovery (Fukushima: $p < .01$; Miyagi: $p < .05$). On the other hand, in the Iwate sample, a change in the relationship tended to enhance the life recovery ($p < .01$). The coefficient in the Fukushima sample was twice that of the others. The interpretation of these differences in the variable parameters is discussed in the next section.

Community involvement. Community involvement did not have a significant effect on life recovery in the three models.

Physical/mental stress management. Mental and physical stress had significant negative effects on the life recovery score in each model ($p < .01$).

Livelihood. The subjective household financial situation significantly affected life recovery in all models. In terms of coefficient, there are large differences for worsening and getting better in the Fukushima and Iwate models. On the other hand, it should be noted that the difference in coefficient was relatively small in the Miyagi model.

Preparedness/relation to the government. The main effect of preparedness/relation to the government was not significant. However, the interaction term tended to have higher life recovery scores in the Fukushima and Iwate models. This means that those who give importance to both self-help and mutual help showed positive effects on life recovery. To understand this result, **Fig. 5** shows the impact of public help vs. mutual help on the life recovery score by the level of self-help. The figure shows that the life recovery is higher among those with high self-help scores and those who value mutual help.

House damage. The degree of house damage did not have consistent effects on life recovery scores in the three models. Partial house damage had significant positive effects on life recovery in the Iwate model.

3.2.3. Comparisons of Parameter Effect Size

The main purpose of the current study was to identify the similarities and differences among the three prefectures in terms of which critical elements were relatively more important in determining life recovery. Therefore, in addition to the coefficient, **Table 1** shows the effect sizes of the seven critical elements on the last columns in each model. **Fig. 6** shows a comparison of these effects sizes (*partial* η^2) of the seven critical elements in the three models. Physical/mental stress management and preparedness/relation to the government have more than two continuous variables. Therefore, to compare them

Table 1. Multiple regression (GLM) analysis of house damage and SCEM effects on life recovery.

	Variables	Fukushima Sample			Iwate Sample			Miyagi Sample		
		B	S.E.	partial η^2	B	S.E.	partial η^2	B	S.E.	partial η^2
Degree of the house damage	Partial Destruction	.547	.925	.001	3.099***	1.052	.025	−.574	.869	.001
	Large-Scale Partial Destruction	1.673*	.930	.012	1.786	1.766	.003	.086	1.012	.000
	Complete Destruction	.917	1.491	.001	−.586	1.242	.001	−.033	1.284	.000
	No Damage (baseline)	–	–	–	–	–	–	–	–	–
Housing	Satisfaction of Housing	.974***	.337	.030	1.494***	.345	.052	1.683***	.342	.064
Social Ties	Change in Relationship with Neighbors	2.284***	.490	.073	.832*	.473	.009	1.104**	.530	.012
Community involvement (residents)	Socialize Very Often and Participate Well in Community Events	1.375	1.242	.004	1.156	1.228	.003	.833	1.231	.001
	Socialize to a Certain Degree and Some Greet Each Other	1.473	1.126	.006	.356	1.143	.000	1.663	1.069	.007
	Do Not Socialize But Neghborhood Representatives Seem to Be More or Less Active	1.565	1.842	.003	.834	1.386	.001	−0.464	1.458	.000
	Do Not Socialize With Each Other and Live By Themselves (baseline)	–	–	–	–	–	–	–	–	–
Physical/mental stress management	Mental Stress	−3.447***	.412	.204	−2.746***	.386	.128	−2.519***	.414	.095
	Physical Stress	−2.224***	.383	.110	−1.842***	.442	.048	−2.396***	.415	.086
Livelihood (subjective household financial situation)	Getting Better	6.489***	1.443	.069	6.754***	1.548	.052	4.388***	1.21	.036
	No Change	2.792***	.892	.035	1.800**	.820	.014	2.785***	.875	.028
	Worsening (baseline)	–	–	–	–	–	–	–	–	–
Preparedness/Relation to Government	Priority in Self Help	.766	.728	.004	.984	.687	.006	.588	.689	.002
	Priority in Mutual help vs Public help	−1.036	.930	.005	−.554	.847	.001	.005	.920	.000
	Priority in Self Help * Priority in Mutual Help vs Public Help	3.609*	1.995	.012	3.036*	1.779	.008	.725	1.796	.000
	Intercept	25.748***	1.916	.397	28.827***	2.165	.339	28.308***	2.243	.311
	R2 (adjusted R^2)	.538 (.513)			.340 (.311)			.370 (.343)		
	N	290			361			369		

***: $p < .001$, **: $p < .05$, *: $p < .010$

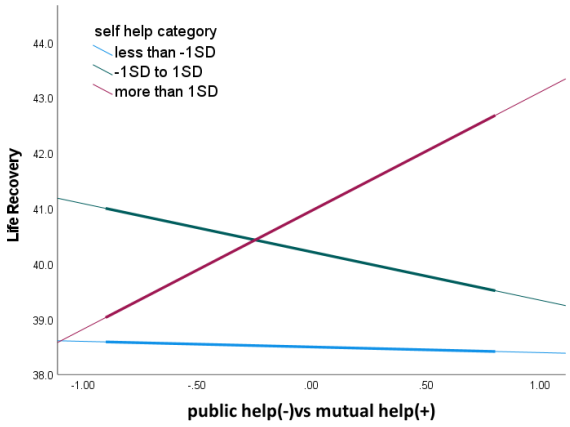

Fig. 5. Interaction effect of preparedness/relation to government.

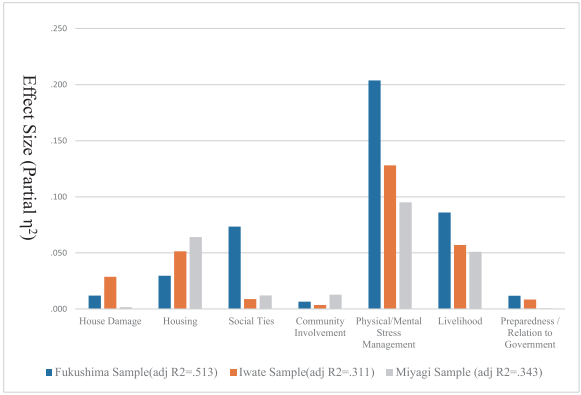

Fig. 6. Comparison of effect size (partial η^2) among three prefectures.

with other critical factors, mental stress and the interaction term of preparedness/relation to government were used as a representation of the factors in **Fig. 6**. This is because these variables have the largest effect size for each factor.

The factor that had the largest effect size was physical/mental stress management in all models. However, the factor that had the second-largest effects depended on the model. This means that the relatively important factors in predicting life recovery differ among the three prefectures. The Fukushima model of effect size had the following features: 1) the effect sizes of physical/mental stress management were larger than those of the other factors, 2) the effect sizes of social ties were higher than those of the other factors, 3) the effect size of housing was lower than that of the other factors. In the Iwate model, the effect size of housing damage was smaller than that of the other factors. In the Miyagi model, 1) the effect size of housing was larger than that of the other factors, 2) the effect sizes of house damage, physical/mental stress management, livelihood, and preparedness/relation to government were lower than those of the other factors.

4. Discussion

This study compared the impact of seven critical elements on life recovery among three prefectures. We found

some similarities and many differences. We discuss the interpretation of our results below.

4.1. The Distribution of Life Recovery

The distributions of life recovery scores are shown by the first analysis. Based on the kernel density estimate results, there are no differences among the three prefectures in terms of the shape of the distribution. After that, the analysis of variance showed that respondents who live in Miyagi have higher life recovery levels than those who live in the other prefectures.

It is thought that the similarity of distribution shapes in the three prefectures affected by a certain disaster demonstrates the external validity of the life recovery score scale. If the distributions differ according to the affected areas, they lack generality as a scale. The difference between the current survey (Fukushima, Iwate, Miyagi) and the 2001 Hanshin survey was the result of when the survey was conducted. The current survey was conducted five years after the Great East Japan Earthquake disaster. On the other hand, the 2001 Hyogo survey was conducted six years after the Great Hanshin-Awaji Earthquake. The 2003 Hyogo survey reported that the variance in the life recovery score increased over time [27].

The local economy is also critical for life recovery, in addition to household financial situations. Kawami et al. noted that the gross regional product in each municipality significantly affects life recovery [28]. The problem is how the dependent variable affects life recovery differently. In the next section, we focus on this topic.

4.2. Result of GLM model

4.2.1. Comparison of Model Fit

The three GLM model fits indicate that the seven critical elements explain the life recovery of the Fukushima respondents well. On the other hand, these factors were less important in determining the life recovery of Iwate and Miyagi respondents. To predict the life recovery of Iwate and Miyagi respondents more precisely, other factors are needed.

Considering that the Fukushima respondents had a lower average life recovery (**Fig. 4**), it is possible that the importance of the seven factors differs depending on the recovery phase. On the contrary, in the Miyagi and Iwate Prefectures, where daily life was returning to normal, the importance of the seven basic elements of life was relatively low.

4.2.2. Coefficient and Effect Size

Two points are shown in the Fukushima model. 1) The effect sizes of physical/mental stress management were larger than those of the other models, and 2) the effect sizes of social ties were higher than those of the other models. It was thought that these features were caused by the nuclear disaster. Overall, 33.8% of respondents who lived in Fukushima Prefecture experienced or were experiencing *diaspora* (nuclear disaster-caused displacement).

Table 2. Correlation between life recovery and social ties by diaspora experienc.

	Those who have not experienced diaspora	Those who have experienced diaspora
Corrolation	.197**	.304**
N	410	139

**: $p < .01$

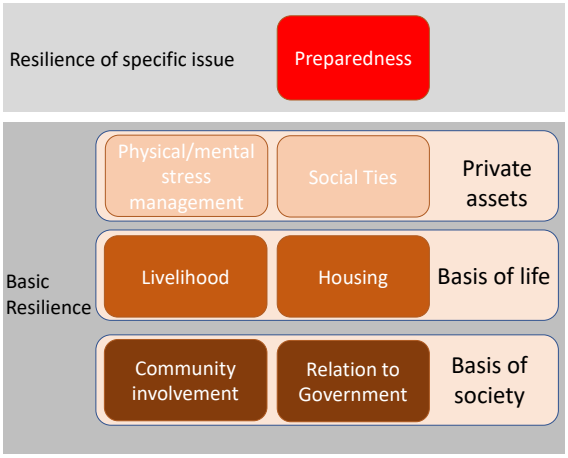

Fig. 7. Seven elements of life recovery and resilience [4].

In fact, that they could not return to their houses, cities, and communities caused them stress (see Appendix A).

Moreover, the *diaspora* may be the background of why physical/mental stress management and social ties had larger effect sizes on life recovery in the Fukushima model than in the other models. Diaspora experiences severed their relationships with their family, friends, and neighborhood before the disaster (see Appendix A). In other words, even if diaspora cannot be avoided, it can potentially promote better recovery by alleviating stress and facilitating relationships with local people and communities. **Table 2** shows the correlation between life recovery and social ties (changes in relationships with neighbors) by diaspora experience. The correlation in those who had experienced diaspora was higher than that in those who had not experienced diaspora. This means that if forced diaspora can create good relationships with local people, the positive effects of social ties on life recovery are more significant than those who have not experienced diaspora. According to Tatsuki et al., "encounter[ing] significant others" promotes better life recovery via event evaluation [19]. Life recovery could be enhanced by encountering new significant others in the wake of diaspora. Therefore, support to encounter significant others in the new community is needed for those who have experienced diaspora.

Finally, the differences in the effects of the seven critical elements among the three models are discussed. Hayashi summarized these seven critical factors in the context of resilience (**Fig. 7**). The seven elements can be divided into four categories [2]. Physical/mental stress

management and social ties can be regarded as private assets in the context of resilience. It is clear that private assets play an important role in life recovery for those who lived in Fukushima as the basis of life and the basis of society were destroyed by diaspora. Therefore, recovering and rebuilding their resilience following the disaster becomes a problem for future research to build back better.

Community involvement has no significant effect on life recovery. In the current study, the sample was divided into three datasets to compare the three models. This might be the trigger that decreases the variance in community involvement. In a study that did not divide the sample but used the same dataset as this study, Kawami et al. verified the effect of community involvement on life recovery [29].

5. Conclusion

In the current study, the similarities and differences among the three prefectures in terms of which critical elements were relatively more important in determining life recovery were studied. From the analysis of the random sampling survey, two findings were obtained. 1) Although there are no differences in the distribution shapes of life recovery, those affected in Miyagi show significantly high life recovery. 2) For those affected in Fukushima, physical/mental stress management and social ties have a substantial impact on life recovery, and these effects were caused by diaspora.

In this study, life recovery was compared at the prefecture level. As a future task, a comparison at a smaller level is needed to reveal the life recovery process. In addition, to verify the causal effects of dependent variables on life recovery, a panel survey is also needed.

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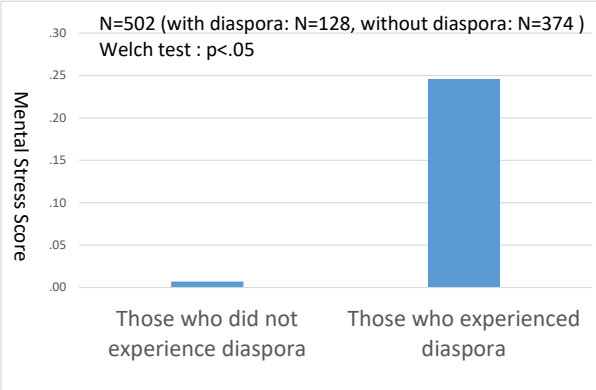

Fig. 8. Diaspora and mental stress in the Fukushima sample.

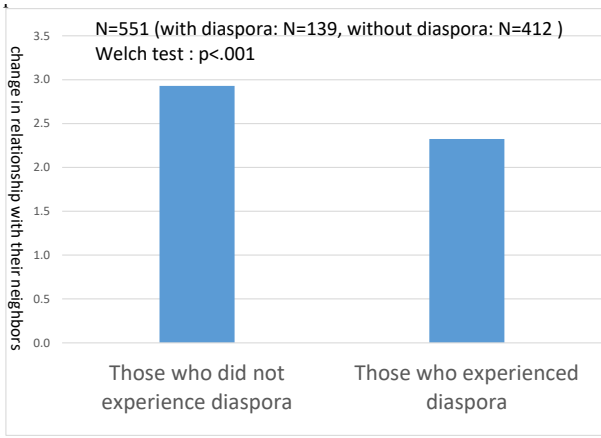

Fig. 9. Diaspora and change in participants' relationships with their neighbors in the Fukushima sample.

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Appendix A.

Figures 8 and **9** shows the influence of the diaspora experiences in Fukushima sample.

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