Disaster Resilience and Egocentric Network Structure: Efficacy of Egocentric Network Characteristics over Individual Disaster Preparedness

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Abstract

Due to developing community resilience, identification of resilience and vulnerability is vital for the local community to conduct interventions. This study explores the determinants of individual disaster preparedness in social network context in the rural community of Japan. Data used in the analysis was derived from the survey in a rural community, Kuroshio Town, Kochi Prefecture. In the analysis, egocentric network measures, social demographic characteristics, and media usage are examined. The result reveals five predictor variables that Agresti's index of qualitative variation (IQV), age, reading habit of publicity paper, possession of radio and cell phone. The findings confirm that diversity rather than cohesiveness in personal network structure was a crucial factor for disaster preparedness in a rural community with geographical immobilisation. Moreover, community information seeking behavior was the primary predictor to the readiness. Based on these insights, some recommendations for practical implementations are discussed.

要旨

コミュニティ・レジリエンスの向上に向けて地域コミュニティによる介入を実施するためにも、住民における防災強者と防災弱者の把握は重要である。本稿では、地方郡部における個人レベルの防災準備行動を規定する要因の探索を、社会ネットワーク論的な文脈から行う。分析に使用したデータは高知県幡多郡黒潮町での社会調査によって収集したものである。分析では、住民の防災力に対するエゴセントリック・ネットワーク指標、人口統計学的属性、メディア使用の影響について検証された。結果として、IQV（質的変動指数）、年齢、慣習的な広報誌の閲読、ラジオおよび携帯電話の所有が予測変数として統計的に有意となった。今回の分析結果から、移動性の低い郡部コミュニティ住民の防災行動に対しては、パーソナル・ネットワーク構造における結束性よりも多様性のほうが重要な規定因であることが判明した。さらに、住民の防災力を規定する最も主要な要因は地域情報収集行動であることも判明した。最終的には、これらの知見から導き出された実践面への助言について論じる。

1. Introduction

Disaster resilience has been focused in Japanese society, especially after the experiences of the 2011 Great East Japan Earthquake. Revision of a risk management plan that can be adapted to the occurrence of an unanticipated disaster become an urgent policy issue to the communities at risk of natural hazards. The idea of resilience become the key to a risk management despite its various concept. An academic debate over the idea of social resilience to hazards has been continued for decades since Holling (1973) defined resilience from an ecological perspective (Klein et al., 2004; Manyena, 2006; Cutter et al. 2008). The resilience concept is not reaching consensus, and still multifarious to transform into an operational tool for policy and management (Klein et al., 2004). Paton (2006) illustrated a disaster resilience as the interaction of adaptive capacities at three levels, namely individual, community, and social/institutional level, and the processes of readiness, response and recovery at catastrophic disaster events. Recent disaster studies underscore the importance of preparedness process (Aldunce et al., 2014; Mileti, 1999; Handmer & Dovers, 1996).

The study reported in this article examines how predictor variables related to social network configurations may affect individual's disaster preparedness in the rural community of Japan. People's attitudes and behaviors are made primary through interpersonal influences, not formed with a direct response to its attributes (Erickson, 1988). Social network analysis approach captures interpersonal influence from the relational aspect of individuals and network structure (Scherer & Cho, 2003; Marsden & Friedkin, 1993; Friedkin & Johnsen, 2011). First, the author reviews previous studies of disaster studies applying social network theory. Secondly, the author predicts hypotheses of how interpersonal network affect individual's disaster preparedness. Then empirical data from Kuroshio Town is analysed to test hypotheses presented in this article. Finally, the author reached a conclusion that the diversity, rather than cohesiveness, in personal network structure, and community information seeking behaviors were the significant predictors of individual disaster preparedness.

2. Background

2.1. Social Network Theory in Disaster Studies

Disaster studies with social network approach were not a popular arena in academics. Varda et al. (2009) argued an importance of social network methodology toward disaster study to assess disaster recovery and relief at the individual and organisational level. The previous individual level disaster studies with social network methodology found out that prior evacuation experiences, as well as races and strong social support, were significant predictors of evacuation at the hurricane situation but not network sizes (Riad et al., 1999); revealed correlation between household resilience and network centrality at a rural village in Botswana (Cassidy & Barnes, 2012); elucidated that the both strong and weak social ties were crucial for vulnerable minority population of Latinos during the Hurricane Katrina in 2005 (Messias et al., 2012).

An interest in recent disaster studies applying social network methodology has been shifted to interorganizational interactions and relations during or after catastrophic events. Those previous studies suggested positive correlation interconnection and coordination of inter-organizational multi-sector emergency response

network (Hossain & Kuti, 2010); elucidated network structural factors that led unsuccessful response using intergovernmental and interorganizational coordination both at Hurricane Katrina and Rita in 2005 (Kapucu et al., 2010); revealed that the organization which has strong ties as well as stable and focused networks tended to be highly resilient within interorganizational networks of disaster-struck organizations after Hurricane Katrina (Doerfel et al., 2013). Social network methodology enables us to analyse a relational aspect of multi-levels of individual, dyad, group or organisation, and interorganization simultaneously (Monge & Contractor, 2003).

2.2. Disaster Preparedness studies

A few disaster preparedness studies applied social network methodology. There were studies clarified that age, income, network density and local economic conditions had significant effects on support provision in the preparation phase of Hurricane Andrew in 1992 (Haines et al., 1996); found out that individual embedded in higher-density and gender-diverse network activated core network ties for informal support in a situation of hurricane (Hurlbert et al., 2000); confirmed the importance of network variables, for example, network size of encouraging or discouraging preparation, in response to 1994 Northbridge, California, earthquake (Heller et al., 2005).

Other than social network theory, there were several previous studies in the field of social psychology focus on disaster preparedness (Mileti & Darlington, 1997; Sattler et al., 2000; Solberg et al., 2009). Those studies revealed that a previous disaster experience promote adoption of protective actions (Mileti & Darlington, 1997; Sattler et al., 2000) as well as personal characteristics and distress (Sattler et al., 2000), and the issues of norms, trust, power, and identity must be more considered than social attributes in the updated model of seismic adjustment at international levels (Solberg et al., 2009). Still, there was no consensus reached on predictors of disaster preparedness in academics (Wachinger et al., 2013).

2.3. Resilience and a flow of information and influence

A flow of information and social influence is a crucial factor of one's decision-making in its attitudes and behaviors. Since most people are apathetic about the natural hazard and its risk (Sandman, 1993), a risk communication takes an important role in the disaster preparedness. Rohrmann (2000) described that '(t)he notion of risk communication (RC) refers to a social process by which people become informed about hazards, are influenced towards behavioral change and can participate in decision-making about risk issues'. Despite the efforts of risk communication and public education, the level of disaster preparedness tends to be lower than expected (Lindell & Whitney, 2000; Paton & Johnston, 2001). It was argued that there is a risk perception paradox that individuals with high-risk perception still choose not to prepare themselves personally in the face of a natural hazard (Wachinger et al., 2013). Network theory of contagion suggests interpersonal effects over individuals' perception as well as their attitudes and behaviors (Christakis & Fowler, 2013; Monge & Contractor, 2003; Burt, 1987; Marsden & Friedkin, 1993). This study will seek how social network structures affect individual's adoption of protective actions toward natural hazards based on social contagion theory.

3. Hypotheses

3.1. Egocentric Network Measures

Interpersonal or *egocentric* networks are ‘those networks that are connected with a single node or individual’ (Kadushin, 2012; p.17). Measures for the egocentric network were classified in previous network studies, for example, the central tendency, tie dispersion, ego-alter similarity (Borgatti et al., 2013; Crossley et al., 2015). Network size or degree centrality is one of the important factors to take protective actions to natural hazards (Hurlbert et al., 2000). Heller et al. (2005) argued that network sizes of encouraging or discouraging preparedness as well as “instrumental support provided” were significantly associated with disaster preparation actions. In this study, the author therefore predicts

Hypothesis 1 (H1): Individuals who embedded in larger social network are more likely to take disaster preventive action than who do not.

The strong tie with others or cohesion may positively affect individuals’ preparedness since the attitudes and behaviors of others to whom they are directly connected influence network members (Monge & Contractor, 2003). Risk perception was influenced by others who made linkages (Scherer & Cho, 2003). Also, core network ties, which overlapped to “bonding social capital” such as family and kins, was activated during and after catastrophic events, even in the planning process (Hurlbert et al., 2000; Hawkins & Maurer, 2010). These previous studies indicated following prediction that

Hypothesis 2 (H2): Individuals who embedded in a cohesive social network are more likely to take disaster preventive action than who do not.

Crossley et al. (2015) explained that tie dispersion is reflecting “weak ties” (Granovetter, 1973). Weak ties are more important than strong ties in the probabilities of accessing new information and resources (Granovetter, 1973, 1983; Friedkin, 1982; Weimann, 1983; Goldenberg et al., 2001). Information flow and social linkages may influence individuals risk perception (Scherer & Cho, 2003). The author, therefore, predicts

Hypothesis 3 (H3): Individuals who embedded in the diverse social network are more likely to take disaster preventive action than who do not.

Hurlbert et al. (2000) suggested that predictor variables, other than network size or density, alters’ proportion of men, average age, gender diversity, and proportion of kin were significantly associated with the activation of network ties in the preparation phase. The author therefore predicts

Hypothesis 4 (H4): Individuals who connected to alters that are a higher average age, more men, different gender, or more kins are more likely to take disaster preventive action than who do not.

3.2. Social Demographic Characteristics

Disaster preparedness research suggested that some social demographic characteristics affect individuals' adoption of preventive behaviors (Haines et al., 1996; Hurlbert et al., 2000; Heller et al., 2005; Mileti & Darlington, 1997; Sattler et al., 2000; Solberg et al., 2009; Wachinger et al., 2013; Russell et al.,1995). Social demographics of age is the controversial factor in preparedness studies. In general, the preparation efforts was positively associated with age (Satter et al., 2000; Lindell & Whitney, 2000; Mileti & Darlington, 1997). However, some studies argued that older adults be less likely to engage in preparation activities (Heller et al., 2005; Aldrich & Benson, 2008). Under the circumstance of rapidly aging population in Japanese society, the author, therefore, predicts

Hypothesis 5 (H5): Older adults are more likely to take disaster preventive action than younger adults.

The gender difference was argued in several types of research in disaster preparedness. Some argued that men be more likely to adopt protective behavior to natural hazards (Finucane et al., 2000; Ho et al., 2008). Contrary, the other studies elucidated that women are more likely to take preparedness actions (Lemyre et al., 2007; Levac et al., 2012). Considering that Japanese households still showed slightly effects of the idea of the division of labour by gender role, the author, therefore, predicts

Hypothesis 6 (H6): Men are more likely to take disaster preventive action than women.

Socioeconomic status may correlate disaster readiness. Individuals with a higher income and better education are more likely to be prepared because they have greater access to resources related to disaster preparedness and hazard mitigation (Russell et al., 1995; Sattler et al., 2000; Sutton & Tierney, 2006; Tierney et al., 2001; Muttarak & Pothisiri, 2013). The author therefore predicts

Hypothesis 7 (H7): Individuals who attained a higher income and better education are more likely to take disaster preventive action than who do not.

The result of the previous study that showed the younger generation of age 30 to 40 living with their family scored higher preparedness (Heller et al., 2005). Responsibility to family members may affect individual's attitudes and actions. The author, therefore, predicts

Hypothesis 8 (H8): Individuals who live with family members are more likely to take disaster preventive action than individuals who live alone.

3.3. Media Usages

Mass media influenced personal risk judgment (Coleman, 1993). Risk perception triggers the process of risk reduction behavior even though there was an only weak correlation between risk perception and disaster

preparedness (Paton et al., 2000). People collect information related to natural hazard and emergency services from mass media channel and interpersonal channels, for example, family members, friends, neighbours, or co-workers (Cretikos et al., 2008). Television news affected personal risk judgment (Coleman, 1993). However, radio was considered more useful than television under some situation (Cretikos et al., 2008). Japanese media environments may categorise media into three types by area of coverage namely national, local and community. National media cover nationwide. While local media cover one or a few prefectural areas, community media only cover a city or a town. The author, therefore, hypothesised

Hypothesis 9 (H9): Individuals who frequently access to local media, such as television, radio, and newspaper, are more likely to take disaster preventive action than who do not.

Hypothesis 10 (H10): Individuals who frequently access to community media, namely CATV and publicity paper, are more likely to take disaster preventive action than who do not.

Recent progress in information and communication technologies (ITCs) changes the way of communication among people at adversity (Shklovski et al., 2008). The Internet and cell phones became crucial communication tools, especially during the natural disaster (Dow & Cutter, 2000; Emani & Kasperson, 1996; Sekiya, 2012). Since a very high penetration rate of cell phones in the Japanese population, the mobile phone operators and the national and local governments had collaborated to introduce a new emergency alert system for cell phones and smartphones (Cabinet Office, Government of Japan, 2012a). From that evidence, the author hypothesised that

Hypothesis 11 (H11): Individuals who own a cell phone (include a smartphone), or use any Internet services are more likely to take disaster preventive action than who do not.

4. Data, Measures, and Methods

4.1. The study situation

At the center of the controversy were residents of Kuroshio Town located at the southwestern part of Kochi Prefecture, Japan. Kuroshio Town has a population of 11,765, and elders (over 65 years old) took 41% of its people (Kuroshio Town, 2016). The town is a typical rural community with decreasing birthrate and aging population, and its industry heavily depends on the primary industry of fishery and agriculture. The town became famous for its highest estimate of the tsunami with the thread of a 34.4-meter inundation in the simulation of the Nankai Trough Earthquake by the Japanese government (Cabinet Office, Government of Japan, 2012b; Cyranoski, 2012).

Mayor Ohnishi and the Kuroshio Town Hall officials were enthusiastically coping with the result of the tsunami simulation and strongly enhance to promote its community resilience by implementing a variety of measures. For example, community resilience workshops have been held at a hazardous inundation areas of 4,600 households to create evacuation plans for every household with help from Town Hall staffs (Ohnishi,

2014).

4.2. Data

The social survey had been carried out as a drop-off/pick-up method survey, self-administered questionnaire at Kuroshio Town between November and December in 2013. Systematic sample of 533 individuals, who age between 20 to 79 years old, were chosen from the electoral roll of the town of 10,541. There were 212 responses and were 209 valid answers. Due to the missing values, 198 data were used in statistical analysis. In the survey, the social network data and demographic attributes, as well as media usage data, were asked.

4.3. Measures

(1) Dependent variable

Disaster Preparedness Score. For the dependent variable, Disaster Preparedness Score (DPS) was created with 22 variables related to disaster preparedness (See Table 1). First three questions asked self-evaluated preparedness, knowledge on evacuation place, and participation in disaster drills, and their answers were coded in ordinal variable scale from 0 (“Not at all”) to 3 (“Very Well”). Next two answers about participation to disaster workshop and planning household evacuation were coded in ordinal variable scale from 0 (“Not at all”) to 2 (“Very Well”). Also, respondents have answered 17 preparedness items which coded whether respondents prepared item (1) and otherwise (0) (See Row 6 to 22 in Table 1). Since scales of variables were different, standardised scores were calculated as z-scores. Then, to assess preparation and to create a preparedness factor, those 22 z-score variables were summed up to DPS. Cronbach’s alpha indicated that the scale had good reliability (α=.810). DPS was ranged from -19.03 to 23.24.

(2) Independent variables

Explanatory variables are composed of three blocks.

Egocentric Network Measures. Basic measures for the egocentric network are referenced to Borgatti et al. (2013) and Crossley et al. (2015). Degree centrality was counted the number of alters in each three relationships, namely a close relationship, a relationship of retrieving local information, and a relationship of consulting disaster prevention. This measure also represented respondent’s social network size. Density without ego was calculated to measure cohesiveness of egocentric network. Agresti’s index of qualitative variation (IQV) (Agresti & Agresti, 1978), which is a normalised version of Blau’s index of heterogeneity (Blau, 1977), was used to measure dispersion or diversity of one’s egocentric network. In this study, IQV of 0.00 means there is no diversity, for example, respondent only has ties to a close relationship. IQV of 1.00 means there is perfect diversity in relationships that same numbers of alters evenly distributed across categories of close relationship, retrieving local information, and consulting disaster prevention. The average age of alters is measured in years. A proportion of men in alters of respondents’ egocentric network was calculated in ratio. To measure gender homophily, EI index (Krackhardt & Stern, 1988) on the gender of alters was calculated. EI index of -1 means that all alters were the same sex as a respondent, and +1 means that all alters were the opposite gender of the respondent. To measure kin relationship tendency, EI index

on the kin relation among alters was calculated. EI index of -1 means that all alters were Ego's kins, and +1 means that all alters were other than kins of the respondent.

Social Demographic Characteristics. Age is measured in years. Gender is coded female (0) and male (1). Education is measured in years. Income is measured with a series of dummy variables. The first coded annual income less than 1 million yen (1) and otherwise (0); the second coded annual income between 1 million and three million yen (1) and otherwise (0); the third coded annual income between 3 million and 5 million yen (1) and otherwise (0); the fourth coded annual income between 5 million and 7 million yen (1) and otherwise (0); the fifth coded annual income more than 7 million yen (1) and otherwise (0). The reference category is no income. A living condition was coded whether respondents live with any family members (1) and otherwise (0).

Media Usage. Possession of media equipment was coded to three measures: whether (1) or not (0) respondents own television, radio, and cell phone (include smartphone). A measure of Internet usage was whether (1) or not (0) respondents use any of Internet services. Subscription of media was coded to two measures: whether (1) or not (0) respondents subscribe local newspaper ("Kochi Shimbun"), and town's CATV. A reading of a publicity paper issued by the town government was coded whether respondents read it habitually (1) and otherwise (0).

4.4. Methods

First, the zero-order correlation between egocentric network measures, social demographic characteristics, and media usage factors was examined. The results showed that only variables between owning a cell phone and using Internet service showed relatively higher correlation (r=.609). The other variables that showed significant correlation were less than r=.500.

Next, single ordinary least square regressions for each 23 independent variables was conducted to select input variables for a final model. The results were shown in Table 3. In the first block of Egocentric Network Measures, degree centrality, IQV, the average age of alters, the proportion of men in alters, and EI Index of the kin relationship were significantly associated to DPS. In the second block of Social Demographic Characteristics, age is only significantly associated the score. In the third block of Media Usage, six variables of owning a television, radio, and a cell phone (including smartphone), subscription of the local newspaper and local cable television, and habitually reading publicity papers were significantly associated with the disaster preparedness.

At last, a hierarchical multiple regression analysis was conducted to examine 12 explanatory variables exposed as significant in the prior step. In this paper, only final block results are reported (See Table 4). The author examined indicators of multicollinearity to ensure that our explanatory factors were not sufficiently correlated to cause problems in the analysis. All statistical calculations were carried out using the Windows SPSS (version 22.0) program.

4.5. Results

When all 12 variables are entered into the model, five factors are statistically significant predictors of DPS

at the p=.05 level; IQV, age, owning radio and cell phone, habitually reading publicity papers (See Table 4). In this model, the parameter estimates (betas) for significant variables, all other variables constant, can be interpreted as follows.

All the five significant variables were positively related to positive DPS. Each one-unit change in IQV was associated with a 4.74-point increase in mean DPS, and this supported *Hypothesis 3*. The association is interpreted as that the average difference in mean DPS between a person with 0.0 (minimum number of IQV) and someone with 1.0 (maximum number of IQV) would be 4.74 points. IQV explained 7.3% of the variance. Age was associated with a 0.14-point increase in mean DPS when respondent's age is older by one year. Age explained 4.1% of the variance. This supported *Hypothesis 5*. Having radio was associated with 2.62 points higher mean DPS compared to not having a radio. Radio possession explained 4.3% of the variance. The result revealed limited support for *Hypothesis 9*. Individuals who habitually read publicity papers of the town was associated with 5.14 points higher mean DPS than an individual who usually do not read a publicity paper. Publicity paper reading explained 11.0 % of the variance. This limitedly supports *Hypothesis 10*. The association between cell phone ownership and DPS was sustained by the findings and this supported a part of Hypothesis 11. Owning cell phone was associated with 4.70 points higher mean DPS than non-owner. Cell phone possession explained 4.8% of the variance.

5. Discussion

Diversity in relations was the only egocentric network measures that significantly associated with DPS. Previous studies showed that network size and density were important factors to disaster preparedness at the individual level (Hurlbert et al., 2000; Heller et al., 2005). There are two possible interpretations to explain this discrepancy. The one is an explanation by "the strength of weak tie" theory (Granovetter, 1973) argued that ego with a mixture of strong and weak ties may have better access to new information and resources than those with just strong ties. Higher IQV allowed individuals to access new information and resources related to risk management of community, and it will enhance individuals to reconsider previous preparation status and give an opportunity to improve one's disaster preparedness. The other possible explanation is by "optimistic bias" theory (Weinstein, 1980; Cohn et al., 1995). The results showed that individuals with a low IQV meant less-prepared and vulnerable in the community. A low IQV indicated that the person was only embedded in one specific type of relationships where everyone in the subgroup knew each other, but no one had a connection beyond its group. Everyone in the group tended to have very similar ideas and values and to share the same subculture. Individuals embedded in a dense social network may have unrealistic optimism bias toward risks derived from natural hazards (Burger & Palmer, 1992). They were prone to evaluate themselves as "well-prepared" comparing to "others" surrounded them who are objectively not enough in the adoption of protective measures (Paton et al., 2006).

Age showed positive association to DPS. The results suggested that residents of Kuroshio Town tended to be more prepared to natural hazard at more advanced ages. In the survey, residents in their 60s and 70s showed a keen interest in protective actions. The result inferred that the elderly population, even the septuagenarian, is active and play a central role in community management. Notwithstanding the result of the survey, there is a possibility still left that relationship between age and DPS is convex curve linear (inverted-U

shape) as indicated in Heller et al. (2005) if the survey included 80 years or older people, which consisted 12.8% of the population.

Disaster resilient individuals took eager information seeking behaviors. The results showed that reading publicity papers of the Town Hall was the primary predictor variable which explained 11.0% of the variance. In the survey, the most selected source of local information was publicity papers issued by the local government, 58.6% of respondents used publicity paper for retrieving disaster-related information. Indeed, publicity paper of Kuroshio Town, "Koho Kuroshio" (Public Relation Kuroshio), published articles of the town's risk management, the national government announcements related disaster and risk management, and basic instructions for disaster preparation by the expert of disaster resilience study. From those facts, it can easily be speculated that individuals who read publicity papers well have accumulated knowledge on the risks of natural hazard and required adjustments. Individual's self-evaluation on their hazard knowledge was correlated to individual's adoption of hazard adjustment activities (Lindell & Whitney, 2000). Differences in reading publicity papers made differences in knowledge and assessments to natural hazard among resident, and this differences may lead difference in adoption of disaster protective behaviors.

The results revealed that possession of a radio and a cell phone significantly associated to DPS. Since radio is critical and trusted information source especially during disaster events (Cretikos et al., 2008), and also a radio is one of the necessary items at disaster (Mulilis et al., 1990), radio possession may become effective predictor to preparedness. On the other hand, cell phone have permeated people's everyday life. People use a cell phone to maintain their social networks (Campbell, 2005; Auter, 2007; Wei & Lo, 2006). In the study, it was conjectured that mobile phone enabled town residents to maintain their personal networks at less social cost and manage their diverse relationships flexibly. Residents who successfully integrated uses of the mobile into their social relationship management may turn out to be more prepared by utilising their various personal networks.

6. Conclusion

The study revealed the relationship between disaster preparedness and egocentric network characteristics and social attributes. The results of the analysis highlight are reading habit of publicity papers, diversity in personal network structure, possession of cell phone and radio, and age as the effective predictors for individual-level disaster preparedness.

The findings in the study support to identify disaster resilient and disaster vulnerable will contribute to improving the town's disaster resilience. The town hall and community leaders can conduct effective interventions to enhance residents' preparedness by focusing on different targets with different approaches. The town hall officials may request well-prepared residents to participate in the revision of the town's risk management plan to be more efficient. Community leaders may approach disaster vulnerable residents by offering an opportunity to gather people and encouraging them to have a contact with someone who shares the same interest to extend their social networks that might lead vulnerable to be more resilient.

The rural profiles of Kuroshio Town that the community along the Pacific coast and surrounded by mountains, and its aging population and less geographical mobility may limit the generalizability of the current findings. A further limitation is that there was implicit assumption that earthquake and tsunami were

the primary risks to its residents, and this makes the findings not adapted to all types of natural hazards. A further weakness is that the survey data did not contain disaster preparedness of alters so that it could not be able to verify the direct effect of social contagion on disaster resilience.

In summary, this study confirms that tie dispersions in personal networks, rather than density, predicted individual disaster resilience. This finding was inconsistent with previous studies (Hurlbert et al., 2000; Hawkins & Maurer, 2010). Diversity rather than cohesiveness in personal network structure was a crucial factor for disaster preparedness in a rural community with geographical immobilisation. Moreover, community information seeking behavior was the primary predictor to the readiness. Disaster resilient individuals were tended to show a keen interest in their surroundings or milieu and to be active on information gathering behavior. On the other hand, younger adults, individuals who embedded in the closed personal network, and the people who showed their interest more on their livelihood than on their environments are a portrait of vulnerable in Kuroshio Town. The community should leverage this disaster vulnerable with some interventions to raise individual- and community-level disaster resilience.

Table 1. Preparedness Items and Disaster Preparedness Score

Disaster Preparedness Items	Unstandardized				Standardized (Z-Score)			
	M	SD	Min	Max	M	SD	Min	Max
1 Awareness of Disaster Preparedness (0=Not awared, 3=Well awared)	1.78	.830	0	3	0	1	-2.15	1.47
2 Knowledge on Evacuation Place (0=Don't know place and name, 3=Knew both place and name)	2.52	.933	0	3	0	1	-2.70	.51
3 Participation in Disaster Drill (0=Don't Know about drill, 3=Knew and participated a drill)	2.26	1.109	0	3	0	1	-2.04	.66
4 Participation in Preparedness Workshop (0=Don't know, 2=Knew and participated a workshop)	1.07	.885	0	2	0	1	-1.20	1.06
5 Planning household evacuation (0=No plan, 2=Made a plan)	.85	.823	0	2	0	1	-1.03	1.40
6 Have battery-operated radio, working flashlight, and first aids (0=No, 1=Yes)	.70	.459	0	1	0	1	-1.53	.65
7 Store water and foods (0=No, 1=Yes)	.44	.498	0	1	0	1	-.88	1.13
8 Furniture secured to wall (0=No, 1=Yes)	.22	.413	0	1	0	1	-.53	1.89
9 Earthquake insurance (0=No, 1=Yes)	.39	.489	0	1	0	1	-.80	1.25
10 Determine a place of shelter in family (0=No, 1=Yes)	.52	.501	0	1	0	1	-1.04	.96
11 Always accumulate water in bathtub (0=No, 1=Yes)	.18	.382	0	1	0	1	-.46	2.15
12 Prepare to save valuables (0=No, 1=Yes)	.27	.444	0	1	0	1	-.60	1.65
13 Sharing confirmation safety methods in family (0=No, 1=Yes)	.19	.395	0	1	0	1	-.49	2.05
14 Living at an aseismic house (0=No, 1=Yes)	.13	.339	0	1	0	1	-.39	2.57
15 Prepare evacuation materials (clothes, blankets) (0=No, 1=Yes)	.17	.374	0	1	0	1	-.45	2.23
16 Always filling up gasoline of car (0=No, 1=Yes)	.21	.406	0	1	0	1	-.51	1.95
17 Have spare batteries (0=No, 1=Yes)	.13	.339	0	1	0	1	-.39	2.57
18 Actively participating disaster drills (0=No, 1=Yes)	.37	.485	0	1	0	1	-.77	1.29
19 Put seismic circuit breaker (0=No, 1=Yes)	.05	.209	0	1	0	1	-.22	4.57
20 Have fire extinguisher (0=No, 1=Yes)	.17	.378	0	1	0	1	-.45	2.19
21 Aware structured support (house bolted) (0=No, 1=Yes)	.08	.265	0	1	0	1	-.29	3.48
22 Others (0=No, 1=Yes)	.02	.122	0	1	0	1	-.12	8.04
Disaster Preparedness Score (DPS)	12.70	5.644	0	23	0	1	-19.03	23.24
Cronbach's alpha		.820				.810		

N=198

Tablel 2. Means and Standard Deviations of Variables Used In Analysis

Independent variables	M	*SD*	Min	Max
Egocentric Network Measures				
Degree Centrality (Network Size)	9.93	9.207	0	55
Density without ego	.22	.201	0.0	1.0
Agresti's IQV (Index of Qualitative Variation)	.71	.394	0.0	1.0
Average age of Alters	51.45	21.644	0	79
Promotion of men in Alters	.39	.325	0.0	1.0
EI index of gender	-.35	.521	-1.0	1.0
EI index of kin	.21	.595	-1.0	1.0
Social Demographic Characteristics				
Age (Years)	59.83	14.457	20	79
Gender (0=Femail, 1=Male)	.44	.498	0	1
Education (Years)	12.12	2.182	9	18
Income				
Income Dummy0 (No income) (reference)	.13	.333	0	1
Income Dummy1 (Under 1 mil. Yen)	.28	.449	0	1
Income Dummy2 (Between 1mil. to 3 mil. Yen)	.32	.469	0	1
Income Dummy3 (Between 3mil. to 5 mil. Yen)	.10	.302	0	1
Income Dummy4 (Between 5mil. to 7 mil. Yen)	.04	.197	0	1
Income Dummy5 (7 mil. Yen or Over)	.02	.141	0	1
Living with any family members (0=Living Alone, 1=Living with family)	.86	.344	0	1
Media Usage				
Owning Television (0=No, 1=Yes)	.73	.444	0	1
Owning Radio (0=No, 1=Yes)	.45	.499	0	1
Owning Cellular Phone (including Smartphone) (0=No, 1=Yes)	.70	.461	0	1
Using any Internet Services (0=No, 1=Yes)	.49	.501	0	1
Subcribing Local Newspaper (0=No, 1=Yes)	.66	.476	0	1
Subscribing Local CATV (0=No, 1=Yes)	.44	.498	0	1
Habitually Read Publicity papers of the Town (0=No, 1=Yes)	.61	.489	0	1

N=198

Table 3. Single Ordinary Least Squares Regression on DPS

Independent variables	B	SE	*β*		R^2
Egocentric Network Measures					
Degree Centrality (Network Size)	.307	.073	.287	***	.082
Density without ego	-4.045	3.498	-.082		.007
Agresti's IQV	9.588	1.650	.383	***	.147
Average age of Alters	.149	.031	.326	***	.106
Promotion of men in Alters	9.006	2.068	.297	***	.088
EI index of gender	-1.660	1.347	-.088		.008
EI index of kin	2.456	1.171	.148	*	.023
Social Demographic Characteristics					
Age (Years)	.137	.048	.200	**	.040
Gender (0=Femail, 1=Male)	-.265	1.413	-.013		0.000
Education (Years)	.221	.324	.049		.002
Income					.007
No income (reference)					
Income Dummy1 (Under 1 mil. Yen)	.427	1.977	.019		
Income Dummy2 (Between 1mil. to 3 mil. Yen)	-.187	1.911	-.009		
Income Dummy3 (Between 3mil. to 5 mil. Yen)	2.469	2.656	.076		
Income Dummy4 (Between 5mil. to 7 mil. Yen)	-.546	3.806	-.011		
Income Dummy5 (7 mil. Yen or Over)	-.765	5.182	-.011		

Living with any family members (0=Living Alone, 1=Living with family)	3.280	2.033	.114		.013
Media Usage					
Owning Television (0=No, 1=Yes)	3.315	1.568	.149	*	.022
Owning Radio (0=No, 1=Yes)	6.354	1.335	.322	***	.104
Owning Cellular Phone (including Smartphone) (0=No, 1=Yes)	4.660	1.491	.218	**	.047
Using any Internet Services (0=No, 1=Yes)	1.710	1.399	.087		.008
Subcribing Local Newspaper (0=No, 1=Yes)	7.198	1.386	.348	***	.121
Subscribing Local CATV (0=No, 1=Yes)	3.071	1.396	.155	*	.024
Habitually Read Publicity papers of the Town (0=No, 1=Yes)	8.741	1.298	.433	***	.188

N=198
* p < .05; ** p < .01; *** p < .001; two-tailed test.

Table 4. Multivariable Ordinary Least Squares Regression on DPS

Independent variables	B	SE	*β*		t	95% CI
Egocentric Network Measures						
Degree Centrality (Network Size)	.045	.070	.042		.644	-.093 - .182
Agresti's IQV	4.737	1.834	.189	*	2.582	1.118 - 8.356
Average age of Alters	.034	.032	.075		1.071	-.029 - .097
Promotion of men in Alters	3.282	1.880	.108		1.746	-.427 - 6.990
EI index of kin	1.380	.949	.083		1.455	-.492 - 3.251
Social Demographic Characteristics						
Age (Years)	.138	.047	.203	**	2.948	.046 - .231
Media Usage						
Owning Television (0=No, 1=Yes)	-1.223	1.466	-.055		-.834	-4.114 - 1.669
Owning Radio (0=No, 1=Yes)	2.619	1.191	.133	*	2.200	.270 - 4.968
Owning Cellular Phone (including Smartphone) (0=No, 1=Yes)	4.696	1.388	.220	**	3.384	1.958 - 7.434
Subcribing Local Newspaper (0=No, 1=Yes)	2.382	1.315	.115		1.812	-.211 - 4.976
Subscribing Local CATV (0=No, 1=Yes)	1.061	1.152	.054		.921	-1.211 - 3.333
Habitually Read Publicity papers of the Town (0=No, 1=Yes)	5.138	1.254	.255	***	4.099	2.665 - 7.612
Intercept	-24.137	3.233			-7.465	-30.516 - -17.758
R^2		.435	***			
Adjusted R^2		.399				
N		198				

* p < .05; ** p < .01; *** p < .001; two-tailed test.

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References

Agresti, A., and Agresti, B. F. (1978), 'Statistical analysis of qualitative variation', *Sociological Methodology*, Volume 9, pp.204-237.

Aldrich, N., and Benson, W. F. (2008), 'Disaster preparedness and the chronic disease needs of vulnerable older adults', *Preventing Chronic Disease*, Volume 5, Number 1, A27.

Aldunce, P., Beilin, R., Handmer, J., and Howden, M. (2014), 'Framing disaster resilience: the implications of the diverse conceptualisations of "bouncing back"', *Disaster Prevention and Management*, Volume 23, Number 3, pp.252-270.

Auter, P. J. (2006), 'Portable social groups: willingness to communicate, interpersonal communication gratifications, and cell phone use among young adults', *International Journal of Mobile Communications,* Volume 5, Number 2, pp.139-156.

Blau, P. M. (1977), *Inequality and Heterogeneity: A primitive theory of social structure* (Vol. 7), Free Press, New York.

Borgatti, S.P., Everett, M.G., and Johnson, J.C. (2013), *Analyzing Social Networks*, SAGE Publications Ltd., London.

Burger, J. M., and Palmer, M. L. (1992), 'Changes in and generalization of unrealistic optimism following experiences with stressful events: Reactions to the 1989 California earthquake', *Personality and Social Psychology Bulletin*, Volume 18, Number 1, pp.39-43.

Burt, R. S. (1987), 'Social contagion and innovation: Cohesion versus structural equivalence', *American Journal of Sociology*, Volume 92, Number 6, pp.1287-1335.

Cabinet Office, Government of Japan (2012a), 'Trying to take advantage of the disaster prevention information' (in Japanese), *Public Relations and Disaster Prevention ("Kouhou Bousai")*, Number 60, pp.4-9.

Cabinet Office, Government of Japan (2012b), *Report on Distribution of Seismic Intensity and Tsunami Height at the Nankai Trough Mega Earthquake (The First Report)* (in Japanese), http://www.bousai.go.jp/jishin/nankai/model/ (accessed 12 June 2016).

Campbell, M.A. (2005), 'The impact of the mobile phone on young people's social life', In *Social Change in the 21st Century Conference, 28 October 2005, QUT Carseldine, Brisbane*. http://eprints.qut.edu.au/3492/ (accessed 12 June 2016).

Cassidy, L., and Barnes, G. D. (2012), 'Understanding household connectivity and resilience in marginal rural communities through social network analysis in the village of Habu, Botswana', *Ecology and Society*, Volume 17, Number 4, 11, http://dx.doi.org/10.5751/ES-04963-170411 (accessed 25 May 2016).

Christakis, N. A., and Fowler, J. H. (2013), 'Social contagion theory: examining dynamic social networks and human behaviour', *Statistics in Medicine*, Volume 32, Number 4, pp.556-577.

Cohn, L. D., Macfarlane, S., Yanez, C., and Imai, W. K. (1995), 'Risk-perception: differences between adolescents and adults', *Health Psychology*, Volume 14, Number 3, pp.217-222.

Coleman, C. L. (1993), 'The influence of mass media and interpersonal communication on societal and personal risk judgments', *Communication Research*, Volume 20, Number 4, pp.611-628.

Cretikos, M., Eastwood, K., Dalton, C., Merritt, T., Tuyl, F., Winn, L., and Durrheim, D. (2008), 'Household disaster preparedness and information sources: Rapid cluster survey after a storm in New South Wales, Australia', *BMC Public Health*, Volume 8, http://www.biomedcentral.com/1471-2458/8/195 (accessed 7 June 2016).

Crossley, N., Bellotti, E., Edwards, G., Everett, M.G., Koskinen, J., and Tranmer, M. (2015), *Social Network Analysis for Ego-Nets*, SAGE Publications Ltd., London.

Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., and Webb, J. (2008), 'A place-based model for understanding community resilience to natural disasters', *Global Environmental Change*, Volume 18, Number 4, pp.598-606.

Cyranoski, D. (2012), 'Tsunami simulation scare Japan', *Nature,* Volume 484, Number 7394, pp.296-297.

Doerfel, M. L., Chewning, L. V., and Lai, C. H. (2013), 'The evolution of networks and the resilience of interorganizational relationships after disaster', *Communication Monographs*, Volume 80, Number 4, pp.533-559.

Dow, K., and Cutter, S. L. (2000), 'Public orders and personal opinions: Household strategies for hurricane risk assessment', *Global Environmental Change Part B: Environmental Hazards*, Volume 2, Number 4, pp.143-155.

Emani, S., and Kasperson, J. X. (1996), 'Disaster communication via the information superhighway: Data and observations on the 1995 hurricane season', *International Journal of Mass Emergencies and Disasters*, Volume 14, Number 3, pp.321-342.

Erickson, B. H. (1988), 'The relational basis of attitudes', in Wellman, B. and Berkowitz, S.D. (ed), *Social Structures: A Network Approach*, Cambridge University Press, New York, pp.99-121.

Finucane, M. L., Slovic, P., Mertz, C. K., Flynn, J., and Satterfield, T. A. (2000), 'Gender, race, and perceived risk: The 'white male' effect', *Health, Risk & Society*, Volume 2, Number 2, pp.159-172.

Friedkin, N. E. (1982), 'Information flow through strong and weak ties in intraorganizational social networks', *Social Networks*, Volume 3, Number 4, pp.273-285.

Friedkin, N.E. and Johnsen, E.C. (2011), *Social Influence Network Theory: A Sociological Examination of Small Group Dynamics*, Cambridge University Press, New York.

Goldenberg, J., Libai, B., and Muller, E. (2001), 'Talk of the network: A complex systems look at the underlying process of word-of-mouth', *Marketing Letters*, Volume 12, Number 3, pp.211-223.

Granovetter, M. (1973), 'The strength of weak ties', *American Journal of Sociology*, Volume 78, Number 6, pp.1360-1380.

Granovetter, M. (1983), The Strength of Weak Ties: A Network Theory Revisited', *Sociological Theory*, Volume 1, pp.201-233.

Haines, V. A., Hurlbert, J. S., and Beggs, J. J. (1996), 'Exploring the determinants of support provision: Provider characteristics, personal networks, community contexts, and support following life events', *Journal of Health and Social Behavior*, Volume 37, Number 3, pp.252-264.

Handmer, J. W., and Dovers, S. R. (1996), 'A typology of resilience: rethinking institutions for sustainable development', *Organization & Environment*, Volume 9, Number 4, pp.482-511.

Hawkins, R. L. and Maurer. K. (2010), 'Bonding, Bridging, and linking: How social capital operated in New Orleans follow hurricane Katrina', *British Journal of Social Work*, Volume 40, Number 1, pp.1777-1793.

Heller, K., Alexander, D. B., Gatz, M., Knight, B. G., and Rose, T. (2005), 'Social and personal factors as predictors of earthquake preparation: the role of support provision, network discussion, negative affect, age, and education 1', *Journal of Applied Social Psychology*, Volume 35, Number 2, pp.399-422.

Ho, M. C., Shaw, D., Lin, S., and Chiu, Y. C. (2008), 'How do disaster characteristics influence risk perception?', *Risk Analysis*, Volume 28, Number 3, pp.635-643.

Holling, C. S. (1973), 'Resilience and stability of ecological systems', *Annual Review of Ecology and Systematics*, Volume 4, pp.1-23.

Hossain, L., and Kuti, M. (2010), 'Disaster response preparedness coordination through social networks', *Disasters*, Volume 34, Number 3, pp.755-786.

Hurlbert, J. S., Haines, V. A., and Beggs, J. J. (2000), 'Core networks and tie activation: What kinds of routine networks allocate resources in nonroutine situations?', *American Sociological Review*, Volume 65, Number 4, pp.598-618.

Kadushin, C. (2012), *Understanding Social Networks: Theories, concepts, and findings*, Oxford University Press, New York.

Kapucu, N., Arslan, T., and Demiroz, F. (2010), 'Collaborative emergency management and national emergency management network', *Disaster Prevention and Management: An International Journal*, Volume 19, Number 4, pp.452-468.

Klein, R. J., Nicholls, R. J., and Thomalla, F. (2004), 'Resilience to natural hazards: How useful is this concept?', *Environmental Vulnerability Assessment Working Paper No.9*, Potsdam Institute for Climate Impact Research.

Krackhardt, D., and Stern, R. (1988), 'Informal Networks and Organizational Crises: An Experimental Simulation', *Social Psychology Quarterly*, Volume 51, Number 2, pp.123-140.

Kuroshio Town (2016), 'Town Data: Population' (Updated June 2nd, 2016), Kuroshio Town Homepage, http://www.town.kuroshio.lg.jp/pb/cont/machi-data/261 (accessed 13 June 2016).

Lemyre, L., Lee, J. E., Turner, M. C., and Krewski, D. (2007), 'Terrorism preparedness in Canada: a public survey on perceived institutional and individual response to terrorism', *International Journal of Emergency Management*, Volume 4, Number 2, pp.296-315.

Levac, J., Toal-Sullivan, D., and O'Sullivan, T. L. (2012), 'Household emergency preparedness: a literature review', *Journal of Community Health*, Volume 37, Number 3, pp.725-733.

Lindell, M. K., and Whitney, D. J. (2000), 'Correlates of household seismic hazard adjustment adoption', *Risk Analysis*, Volume 20, Number 1, pp.13-26.

Lindell, M. K., Tierney, K. J., and Perry, R. W. (2001), *Facing the Unexpected: Disaster Preparedness and Response in the*

United States, Joseph Henry Press, Washington D.C.

Manyena, S. B. (2006), 'The concept of resilience revisited', *Disasters*, Volume 30, Number 4, pp.434-450.

Marsden, P. V., and Friedkin, N. E. (1993), 'Network studies of social influence', *Sociological Methods & Research*, Volume 22, Number 1, pp.127-151.

Messias, D. K. H., Barrington, C., and Lacy, E. (2012), 'Latino social network dynamics and the Hurricane Katrina disaster', *Disasters*, Volume 36, Number 1, pp.101-121.

Mileti, D. (1999), *Disasters by Design: A Reassessment of Natural Hazards in the United States*, National Academies Press, Washington D.C.

Mileti, D. S., and Darlington, J. D. (1997), 'The role of searching in shaping reactions to earthquake risk information', *Social Problems*, Volume 44, Number 1, pp.89-103.

Monge, P. R., and Contractor, N. S. (2003), *Theories of Communication Networks*, Oxford University Press, New York.

Mulilis, J. P., Duval, T. S., and Lippa, R. (1990), 'The effects of a large destructive local earthquake on earthquake preparedness as assessed by an earthquake preparedness scale', *Natural hazards*, Volume 3, Number 4, pp.357-371.

Muttarak, R., and Pothisiri, W. (2013), 'The role of education on disaster preparedness: case study of 2012 Indian Ocean earthquakes on Thailand's Andaman Coast', *Ecology and Society*, Volume 18, Number 4, 51, http://dx.doi.org/10.5751/ES-06101-180451 (accessed 26 May 2016).

National Tax Agency of Japan (2016), 'Report of Statistical Survey on Actual Conditions of Salary in a Private Sector in 2016', http://www.nta.go.jp/kohyo/press/press/2014/minkan/ (accessed 3 June 2016)

Ohnishi, K. (2014), 'How we confront the Nankai Trough Mega Earthquake?: Toward No Victims at Adversity' (in Japanese). *Academia (Japan Academy for Municipal Personnel)*, Number 108, pp.14-19.

Paton, D. (2006), 'Disaster resilience: integrating individual, community, institutional and environmental perspectives', Paton, D. and Johnston, D. (ed), *Disaster Resilience: An integrated approach*, Charles C Thomas Publisher, Ltd, Springfield, Illinois, pp.305-318.

Paton, D., and Johnston, D. (2001), 'Disasters and communities: vulnerability, resilience and preparedness', *Disaster Prevention and Management: An International Journal*, Volume 10, Number 4, pp.270-277.

Paton, D., Smith, L., and Johnston, D. M. (2000), 'Volcanic hazards: risk perception and preparedness', *New Zealand Journal of Psychology*, Volume 29, Number 2, pp.86-91.

Riad, J. K., Norris, F. H., and Ruback, R. B. (1999), 'Predicting evacuation in two major disasters: risk perception, social influence, and access to Resources 1', *Journal of Applied Social Psychology*, Volume 29, Number 5, pp.918-934.

Rohrmann, B. (2000). 'A socio-psychological model for analyzing risk communication processes', *The Australasian journal of disaster and trauma studies*, Volume 2000-2, http://www.massey.ac.nz/~trauma/issues/2000-2/rohrmann.htm (accessed 10 May 2016).

Russell, L. A., Goltz, J. D., and Bourque, L. B. (1995), 'Preparedness and hazard mitigation actions before and after two earthquakes', *Environment and Behavior*, Volume 27, Number 6, pp.744-770.

Sandman, P. M. (1993), *Responding to community outrage: Strategies for effective risk communication*, AIHA, Fairfax, VA.

Sattler, D. N., Kaiser, C. F., and Hittner, J. B. (2000), 'Disaster preparedness: relationships among prior experience, personal characteristics, and distress 1', *Journal of Applied Social Psychology*, Volume 30, Number 7, pp.1396-1420.

Scherer, C. W., and Cho, H. (2003), 'A social network contagion theory of risk perception', *Risk Analysis*, Volume 23, Number 2, pp.261-267.

Sekiya, N. (2012), 'Anxiety and information behaviour after the Great East Japan Earthquake' (in Japanese), *The Journal of information Science and Technology Association*, Volume 62, Number 9, pp.372-377.

Shklovski, I., Palen, L., and Sutton, J. (2008), 'Finding community through information and communication technology in disaster response', In *Proceedings of the 2008 ACM conference on Computer supported cooperative work*. ACM, pp. 127-136.

Solberg, C., Rossetto, T., and Joffe, H. (2010), 'The social psychology of seismic hazard adjustment: re-evaluating the international literature', *Natural Hazards and Earth System Sciences*, Volume 10, Number 8, pp.1663-1677.

Sutton, J., and Tierney, K. (2006), *Disaster preparedness: concepts, guidance, and research*, Natural Hazards Center, Institute of Behavioral Science, University of Colorado, Boulder, www.fritzinstitute.org/pdfs/whitepaper/disasterpreparedness-concepts.pdf (accessed 20 May 2016).

Varda, D. M., Forgette, R., Banks, D., and Contractor, N. (2009), 'Social network methodology in the study of disasters: Issues and insights prompted by post-Katrina research', *Population Research and Policy Review*, Volume 28, Number 1, pp.11-29.

Wachinger, G., Renn, O., Begg, C., and Kuhlicke, C. (2013), 'The risk perception paradox—implications for governance and communication of natural hazards', *Risk Analysis*, Volume 33, Number 6, pp.1049-1065.

Wei, R., and Lo, V. H. (2006), 'Staying connected while on the move Cell phone use and social connectedness', *New Media & Society*, Volume 8, Number 1, pp.53-72.

Weimann, G. (1983), 'The strength of weak conversational ties in the flow of information and influence', *Social Networks*, Volume 5, Number 3, pp.245-267.

Weinstein, N. D. (1980), 'Unrealistic optimism about future life events', *Journal of Personality and Social Psychology*, Volume 39, Number 5, pp.806-820.