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ORIGINAL RESEARCH

Correlating Post-disaster Support Network Density with Reciprocal Support Relation Satisfaction: An Elderly Cohort Within One Year of the 2011 Japan Disasters

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Abstract

While there has been much empirical investigation into how social support networks improve mental health in post-disaster communities, network density—the extent members within a network are acquainted—remains under-researched. This study examines correlations between support network density and support reciprocity satisfaction in an elderly sample ($N = 221$), and the influence on post-disaster depression and trauma symptomology in a fishing community south of the Fukushima nuclear plant within 1 year of the March 11, 2011 Japan earthquake. The Brief Inventory of Social Support Exchange Network (BISSEN) taps support network density, support source by relational category, tangible and emotional type, and providing or receiving direction of social support. Density measurement convergent validity was established from questionnaire responses. After confirming network density construct and criteria validity, and extracting components reciprocal support relationship satisfaction, correlation between these two variables was moderate at $r = 0.34$. However, reciprocity satisfaction moderately explained mental health variance, but results were not significant for density nor interaction between predictors. These results question the assumption that support network density and support reciprocity can be validly incorporated into a construct of "social capital" necessarily promoting mental health.

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Introduction

With the increased frequency of disasters, understanding community factors that contribute to individual positive affective states in "non-routine" situations (Hurlbert et al. 2000) has become more critical. The elderly especially face special risks during disasters (Pietrzak et al. 2013), including increased rates of onset dementia (Hikichi et al. 2016a). Clarifying the mechanisms within communities associated with better mental health outcomes could aid pre-event planning and post-event interventions. Some "social capital" research has focused on social "cohesion" (Bender et al. 2015; Hikichi et al. 2016b; MacGillivray and Walker 2000; Putnam 2001) Another approach is to identify characteristics of social networks that enhance social support and resilience (Abramson et al. 2015). For example, social support networks where members know each other well—i.e., with high density—significantly predict post-disaster support source (Haines et al. 2008; Hurlbert et al. 2000).

For elderly disaster survivors of the 2011 Great East Japan Earthquake, providing post-event support to fellow survivors appears beneficial for mental health (MH). Empirical data showed a potential "buffering" effect against depression with lower screening scores (Lebowitz 2017), and qualitative research suggested it aids reconstruction of social identity against loss of community (Yotsui et al. 2016). Such results correlate with previous research on elderly support providing in non-disaster situations (Brown et al. 2003).

Since reciprocity (Harpham et al. 2002)—balanced "give-and-take" support—and dense ties within support networks (Putnam 2001) are considered dimensions of "social capital," they should associate. However, measuring so requires operationalizing these dimensions empirically from social support data, which is absent from the above "social capital" studies on cohesion. Son and Lin consider networks, but extrapolate network density mainly from organizational membership without specifically tapping support data (Son and Lin 2008). This study examines the possible association between network density and support reciprocity-based satisfaction in cross-sectional social support data from an elderly cohort in the Northeast of Japan impacted by the 2011 disaster. This association is hypothesized to be the mechanism between network density and better post-disaster MH outcomes. If empirical evidence shows the interaction between the tested variables has a significantly beneficial effect—i.e., the magnitude of influence of density on individual post-disaster support behavior contributes to better MH outcomes—then promoting "close-knit" communities is a plausible preventative pre-disaster policy mitigating post-event morbidity. Construct validity of network density and support reciprocity satisfaction are confirmed from data collected for this study. This is a necessary step preceding testing this association empirically, and can provide evidence whether including both constructs under "social capital" is validly sound.

This intervention and study was approved by the ethics committee of the U of Tsukuba, and complied with the principle of voluntariness.

Literature Review

Here we provide an overview of network density and support reciprocity research, including recent research from Japan. The network density construct originated in social anthropology as the key structural aspect of social networks (Hirsch 1980). Defined by Mitchell as "the extent to which links could possibly exist among persons do in fact exist" (Mitchell 1969, p. 18), Barnes suggested quantifying density as "… the extent in which a zone approaches completeness," i.e., number of actual relations in proportion to those theoretically possible (Barnes 1969, p. 63). Following this method, Wellman et al. assigned density values to individual survey respondents by aggregating listed intimates in the numerator and possible number of network ties between each listed member in the denominator (Wellman et al. 1973). More sophisticated mathematical models for calculating density followed, such as Granovetter's formulas for averaging "acquaintance volume" (Granovetter 1976) and Burt's system-wide prediction models based on relational pattern vectors (Burt 1980).

These math models are powerful instruments for census analysis (Marsden 1987). However, what does the number of ties between acquaintances actually reveal? Boissevain believed network analysis clarifies tensions in human relations as "an antidote to the structural–functional preoccupation with consensus, order, balanced opposition, and harmony" (Boissevain 1979, p. 393). Certainly, when correlated with other measures, close-knit networks do not appear uniformly positive. For example, two studies of younger populations (college students and young widows) by Hirsch showed higher support satisfaction levels from less-dense networks, and better mental health scores (Hirsch 1979, 1980). Stokes' results reflected similar ambiguity with a curvilinear relationship between density and satisfaction (Stokes 1983).

Since Boissevain noted relationships could be negative as well as positive, Hirsch's results are not surprising. Another plausible explanation is the "pressure-cooker" effect described by Hobfoll and London, where Israeli women with relatives in combat areas showed aggravated stress levels after sharing concerns with community members in similar circumstances (Hobfoll and London 1986). Although network density is not discussed, feelings of being surrounded by individuals in similar straits may compound worry. That is, networks exert strong social influence on individuals (Berkman et al. 2000; Marsden and Friedkin 1994) positively and negatively. The age and socioeconomic (SES) status of subjects is also important. For example, evidence suggests lower SES associates with higher network density (Morenoff et al. 2001). For minority elderly in a poor US urban community, density associated with lower health (Wen et al. 2005). On the other hand, denser networks appear to buffer at-risk youth against depression (Reynolds and Crea 2015).

While network density is a structural construct, reciprocity is behavioral and considered prosocial (Batson and Powell 2003; Trivers 1971). Potential MH benefits have received attention since feelings of mattering predict lower depression scores in empirical studies (Taylor and Turner 2001). Among elderly, providing

emotional support to a spouse and instrumental support outside the household may increase longevity (Brown et al. 2003). Important East Asian cultural tendencies surrounding giving and receiving may partially explain strong positive associations between providing support and physical or mental health among elderly in Japan, South Korea, and Taiwan (Kim et al. 1999; Lee et al. 2013; Liao et al. 2014; Sung 2003).

Compared to network density, measuring reciprocity appears less standardized. For example, studies from Japan employ different quantitative and qualitative instruments. Quantitative investigations use questionnaire items ("Yes/No" or Likert scale) to tap reciprocity as one factor of social interaction linked to elderly mental wellness (Aida et al. 2011; Hanibuchi et al. 2010; Ichida et al. 2005; Inaba et al. 2015). Yutakajima and Sato's (2014) qualitative study combined detailed questionnaires with face-to-face interviews for 12 participants aged ≥65 years to identify motivations for and against providing social support. Building reciprocal relationships was motivating, reflecting an earlier study (Yanagisawa et al. 2003) deriving two rationale categories for providing support: "community reciprocity," a mode of social extraversion that pays back all past and present debts and "pays-forward" future ones; and individually oriented rationale, such as goals, moral sense, and personality. Iida's (2000) unique study had subjects view cards from the Pictures Affective Relationships Test (PART) (Takahashi and Sakamoto 2000). Daily situations (e.g., drinking tea, taking care of the ill) were illustrated with a blank area to be filled by a potential support member. Reciprocity level was a consistent predictor in self-esteem, self-efficacy, and life satisfaction level.

Data/Methods

Kita Ibaraki City (pop. 45,000) 100 km south of the Fukushima nuclear power plant damaged in the combined earthquake-tsunami disaster of March 11, 2011 sustained massive building damage but limited casualties. It was also impacted by the nuclear accident when ocean-borne radiation disrupted the fishing industry. The population faced risks for mental health morbidity due to loss of its economic base (Adeola 2009; Arata et al. 2000; Galea et al. 2008) and local identity from fishing culture (Gill and Picou 1997). An assessment and intervention program began at the local General Hospital in December as collaboration between the U of Tsukuba, the Kita Ibaraki government, and National Center of Neurology and Psychology (NCNP). The assessment investigated physical and mental health, and social support systems. The sample for this study consists of elderly program participants from the Otsu and Hirakata neighborhoods, $N = 221$ (female: $n = 153$), age 65–94 years ($M = 71.9$, SD = 5.1). Demographic details of this sample have been published previously (Lebowitz 2016a).

The Brief Inventory of Social Support Exchange Network (BISSEN) scale developed by Aiba et al. (2013) contains eight items tapping support subtypes (emotional and tangible), direction (received and provided), relational categories (family, relatives, friends, neighbors, colleagues, and other), density of the networks, and satisfaction levels with the support relationships. It has good psychometric properties

(Aiba et al. 2017). Network density and satisfaction with reciprocal support relationships are the focus of this study. Validity for these variables was confirmed by examining how they converged around the other test variables of subtypes, directions, and relational categories.

Density was tapped by one item each for the receiving and the providing support network: "Do the people from whom you receive emotional and tangible support know each other?" and "Do the people to whom you provide emotional and tangible support know each other?" Likert-scale answers were from 1 "Everybody knows each other" to 4 "Nobody knows each other." These questions directly followed inquiries into which relational categories—immediate family, relatives, friends, neighbors, colleagues, or others—were in the support network for each type of support in each direction (Appendix 1). Cronbach's alpha coefficient of reliability was 0.79. This exceeds the $\alpha > 0.70$ recommended for a newly developed scale (Lance et al. 2006).

Reciprocal support in this study is operationalized as a latent factor composed of two dimensions tapped in the BISSEN scale. Respondents rated satisfaction levels on a Likert scale from 1 = "Very Satisfied" to 6 = "Very Dissatisfied" with providing and receiving social support relationships: "How do you feel about the relationship with the people that support you?" and "How do you feel about the relationship with the people you support?" Here, support "amount" is conceptualized as support relationship quality defined as satisfaction level. Previous studies operationalize reciprocity as satisfaction (Brown et al. 2003; Buunk and Schaufeli 1999), so these items are suitable dimensions of a combined reciprocity manifold. Subscale data had high reliability $\alpha = 0.81$. The subscale responses were non-parametrically distributed, so Spearman's rho (Bishara and Hittner 2015) showed high correlations at $r = 0.70$ ($p < 0.01$). Combining these variables using Principal Components Analysis into one "reciprocity satisfaction" component loaded very highly at 0.915.

Depression symptoms were assessed with the self-reporting CES-D (Center for Epidemiologic Studies Depression Scale) (Radloff 1977) scored on a 4-point scale from "None of the time" to "Most or all of the time," written as "At least five days a week" in the Japanese version. Higher scores indicated more frequent symptoms. The Japanese version has high validity and reliability (Shima et al. 1985) and has been used to research populations displaced by the Miyake Island volcano (Goto et al. 2006), and East Japan earthquake rescue workers concerned with radiation exposure (Matsuoka et al. 2012). The IES-R (Impact of Event Scale—Revised) measures three categories of symptoms—avoidance, intrusive thoughts, and hyperarousal—associated with Post-Traumatic Stress Syndrome (Weiss and Marmar 1997). A Japanese version tested on survivors of the Hanshin-Awaji Earthquake, the Tokyo subway sarin attack, and a neighborhood criminal poisoning showed good validity and reliability (Asukai et al. 2002).

Therefore, to summarize the methodology:

- Validity of the two main variables of concern—network density and satisfaction with reciprocal support relationships—is confirmed.
- Data about receiving and providing support (i.e., subtype, direction, and source category) are reduced to a single reciprocity component.

- Association between network density and satisfaction with reciprocal support relationships is tested.
- Influence these variables exert on MH outcomes of depression and trauma symptomology is examined with analysis of variance.

Statistical analysis was done on SPSS software version 23 for Windows (SPSS Japan Inc., Tokyo, Japan), and correlational comparisons using the procedure developed by Hittner et al. (2003) through the *cocor* package for R programming language by Diedenhofen and Musch (2015). This investigation was carried out in accordance with the latest version of the Declaration of Helsinki, and informed consent of the participants was obtained after the nature of the procedures had been fully explained. This intervention and study was approved by the ethics committee of the U of Tsukuba, and complied with the principle of voluntariness.

Results

Confirmatory factor analysis was performed on relational categories—cohabitating family, relatives, friends, neighbors, colleagues, and other—in the support network to confirm the model of all four support types (2 subtypes of emotional and tangible support × 2 directions of receiving and providing) in each relational category. This confirmed a 6-factor support source model based on these categories (Appendix 2).

Density Scale Validity

Confirming support network density validity is key to this study. To establish density as a construct tapped by the BISSEN scale, density-related responses derived from different sections were compared. More specifically, network density convergent validity was confirmed by comparing correlations between "received" and "provided" support direction responses from two different subscales. First, correlations of responses to "Do the people from whom you receive emotional and tangible support know each other?" and "Do the people to whom you provide emotional and tangible support know each other?" were examined (Rec.DenSubscale × Prov.DenSubscale), with $r = 0.65$, $p < 0.01$.

Next, a different Density Value was derived arithmetically by aggregating responses to BISSEN subscales tapping sources of each support subtype and dividing by total number of support source categories—i.e., six categories—based on Barnes' earlier theory of density as proportion of actual relations to those theoretically possible (Barnes 1969). Therefore, the formula was

(Aggregated categories listed in support subtype)/(6 total support groups) = Density Value.

This provided four subtype by direction support network new Density Values: Received Emotional (RecEmo.DenVal), Received Tangible (RecTang.DenVal), Provided Emotional (ProvEmo.DenVal), and Provided Tangible (ProvTang.DenVal). Then, correlations were derived from similar support subtypes between directions:

RecEmo.DenVal × ProvEmo.DenVal $r = 0.62$, RecTang.DenVal × ProvTang.DenVal $r = 0.63$, both $p < 0.01$.

These between-direction correlations by subtype Density Value correlations were then compared to the $r = 0.65$ between-direction Density Scale correlation. Comparing the two non-overlapping correlations showed that these values are not significantly different: Density Scale Correlation vs. Emotional Support Density Value Correlation $z = 0.62$, $p = 0.54$; and vs. Tangible Support Density Value Correlation $z = 0.35$, $p = 0.73$. In fact, between-direction correlations for the subtype density values and for the density subscale were similarly all in the $r = 0.60$–0.65 range, demonstrating respondent qualitative assumptions about support network density-matched quantitative data from responses, thus indicating the density scale's predictive validity for the density construct.

Reciprocity Scale Validity

To test reciprocity concurrent validity, scores for receiving relational satisfaction (SatRec), providing relational satisfaction (SatProv), and the factor-reduced combined composite as reciprocity satisfaction (SatRecipComp) were correlated with scores for the same sample from the Japanese version of the 12-item General Health Questionnaire (GHQ-12) (Doi and Minowa 2003). The GHQ-12 had good correlations with the CES-D ($r = 0.44$) and IES-R ($r = 0.44$). If correlation coefficients between relational satisfaction scores and the GHQ-12 are not significantly different, there is concurrent validity for subscales and the combined "reciprocity satisfaction composite." No significant differences were found between these correlation coefficients, confirming construct validity for the relational support satisfaction subscales and reciprocity composite (Table 1).

Reciprocal satisfaction composite convergent validity was confirmed by examining correlations between this variable and support subtypes (emotional and tangible) for each relational category in both support directions (receiving and providing). This is based on the assumption reciprocity satisfaction derives from being repaid in kind—emotional for emotional, and tangible for tangible—within a specific support relationship (i.e., relational category). Testing this assumption, first Cronbach's alpha reliability for both support subtype directions was examined in each relational

Table 1 Comparisons of relational support satisfaction × GHQ-12 and composite × GHQ-12 correlations

	SatRec	SatProv	GHQ-12	SatRecipComp
SatRec	1			
SatProv	0.70**	1		
GHQ-12	$0.15^{*,1,2}$	$0.19^{**,1,3}$	1	
SatRecipComp	0.93**	0.90**	$0.19^{**,2,3}$	1

$^{**}p < 0.01$; $^{*}p < 0.05$. r comparisons: $z^1 = -0.71$, $p = 0.48$; $z^2 = 1.57$, $p = 0.12$; $z^3 = 0.14$, $p = 0.89$

SatRec Satisfaction w/Receiving Support Relationship, *SatProv* Satisfaction w/Providing Support Relationship, *SatRecipComp* Reciprocity Relation Satisfaction Composite

support source category. Emotional support subtypes and tangible support subtypes within a relational category were made into subtype composites across both directions of support (Table 2).

After obtaining a correlation coefficient between these subtype composites and the reciprocal satisfaction composite, these coefficients were compared among themselves. If there were not significant differences between the subtype composite × reciprocal satisfaction correlations within a relational category, this suggests convergent validity for the reciprocal satisfaction composite. As relational categories are not predictor variables in this study, individual low subtype composite × reciprocal satisfaction correlations are not of interest. All correlations are not significantly different at 0.01 probability alpha level. The reason the "other" category was close to significance maybe due to difficulties in how it is defined especially concerning "tangible" support. Factor loadings for each bi-directional support subtype composite were ≥ 0.80. This should not be considered contradictory to lower reliability values since this test does not express any information about factor structure (Sijtsma 2009). Moreover, Cronbach's alpha may only represent the lower bound of a reliability confidence interval (Zinbarg et al. 2005).

Correlating Reciprocity with Density

Overall, validity was established for network density and reciprocity variables tested by the BISSEN scale. Next, these variables were correlated. Here, the reciprocity relationship satisfaction variable is a composite from questionnaire items concerning receiving and providing support relationship satisfaction. Support network density is also a composite of receiving and providing network density data (0.91 factor loadings). Results concerning the influence of these variables on MH outcomes

Table 2 Within-subtype receiving × providing *r*-correlations (A), within-support source bi-directional (receiving and providing) Support Composite Emotional × tangible *r*-correlations (B), bi-directional subtype composite × reciprocity relation satisfaction composite *r*-correlations (C), $\alpha = 0.01$

Support subtype/support source	A (Cronbach's α)	B	C	C *z*-comparisons (*p*)
Emotional/family	0.72 (0.74)	0.72	−0.11	0.31 (0.75)
Tangible/family	0.78 (0.65)		−0.09	
Emotional/relative	0.57 (0.73)	0.74	−0.16	0.57 (0.57)
Tangible/relative	0.61 (0.76)		−0.19	
Emotional/friend	0.57 (0.73)	0.64	−0.14	1.10 (0.27)
Tangible/friend	0.61 (0.76)		−0.20	
Emotional/neighbor	0.51 (0.68)	0.67	−0.22	−0.56 (0.57)
Tangible/neighbor	0.48 (0.65)		−0.19	
Emotional/colleague	0.72 (0.83)	0.59	−0.10	−1.91 (0.06)
Tangible/colleague	0.59 (0.74)		0.02	
Emotional/other	0.50 (0.66)	0.64	0.06	2.52 (0.012)
Tangible/other	0.28 (0.43)		−0.08	

should be considered in this context, and potential shortcomings are presented in Discussion section.

Correlation between these two composite variables was moderate at $r = 0.34$, $p < 0.01$. This would appear to support social capital's proposal including both variables within a social capital construct. However, since social capital is believed to support mental health, it is also necessary to see if outcome symptomology can be explained by both variables, and if there is a significant outcome from their interaction. That is, how much does the magnitude of influence from one composite variable on MH outcomes depend on the other composite variable?

To understand this, a two-way factorial ANOVA was performed. Satisfaction with reciprocal support relations had a significant effect on depression symptomology measured by the CES-D: $F(12, 221) = 2.87$, $\eta^2 = 0.17$, $p < 0.001$. The influence exerted by bi-directional support network density was not significant: $F(7,221) = 1.46$, $\eta^2 = 0.06$, $p = 0.19$. Results for trauma symptomology from the IES-R were similar: reciprocity relationship satisfaction was significant, $F(12,221) = 2.78$, $\eta^2 = 0.16$, $p < 0.01$, but bi-directional support network density was not, $F(7221) = 1.45$, $\eta^2 = 0.06$, $p = 0.19$. Levene's test for equality of variances showed between-group variances were not significantly different for both outcomes. In consideration of a model incorporating both factors of density and reciprocity, it was necessary to examine the effect of their interaction on MH outcomes. In either case, the influence exerted by one variable on the outcome was not significantly modulated by the other variable: for depression symptoms, $F(18,221) = 0.49$, $\eta^2 = 0.05$, $p = 0.96$; for trauma, $F(18,221) = 1.12$, $\eta^2 = 0.10$, $p = 0.34$.

Discussion

This study, in examining the correlation between post-disaster satisfaction with reciprocal support relationships and support network density, made considerable effort to establish validity for these variables. Construct validity was examined closely since predictor variables were composites of questionnaire data. While clearly confirmed for network density, reciprocal support satisfaction showed some concerns in the "other" category. Differences in correlations between support subtype composites in this category and the reciprocity relationship satisfaction composite were close to significant. As mentioned earlier, this may be due to "other" not being a clear relational category. However, discriminant validity between this category and others was plausibly established.

Next, correlations were examined between support network density and relational support satisfaction for reciprocity using composites derived from BISSEN data. The correlation was moderate. Then, effect sizes on the two mental health outcomes of post-disaster depression and trauma were analyzed, plus their interaction. Bi-directional network density did not significantly explain variance in either of the MH outcome scores. Previous research has also shown both positive and negative associations between network density and mental health. The ANOVA showed a moderate effect size from satisfaction with reciprocal support relations. Among reciprocity research from Japan reviewed earlier, Hanibuchi et al. (2010) also found

a positive association with self-rated health, although Inaba et al. did not (2015). However, the interaction effect between bi-directional network density and reciprocal support relation satisfaction was not significant.

A potential weakness of this analysis is the two predictors for MH were composites created from BISSEN data. To examine if effects were consistent, a similar analysis was run on the variables in their original form (Table 3), i.e., within their original direction of receiving and providing. The ANOVA showed receiving support relational satisfaction significantly explained some variance for both MH outcomes at $p < 0.05$. Received support network density also significantly explained some trauma symptom variance. Neither MH outcome was explained significantly by providing support relational satisfaction nor providing support network density. However, consistent with ANOVA results for composite variables representing reciprocity, interactions between predictor support variables within support directions had no significant effects on outcome MH variables. This lack of an interaction effect calls into question having both variables under a model of "social capital" as Son and Lin assert "density of interactions and therefore reciprocal social relations, as properties of social networks, constitute 'capital'" (Son and Lin 2008, p. 333).

Besides methodology, this study has other potential limitations regarding the volunteer, self-reporting sample. No pre-disaster data regarding depression was available, nor cognitive testing for dementia often associated with depression. These issues, together with the cross-sectional design, make it impossible to draw direct causative correlations between disaster events and mental health. However, an earlier study with the same sample regarding personal levels of disaster impact indicated effect sizes from house damage and other predictors consistent with

Table 3 Two-way factorial ANOVA: within-direction support relation satisfaction and network density on MH outcome

Source	df	*F*	*p*	Partial η^2
CES-D (*depression symptomology screening*)				
SatRec	3	**3.85**	**0.01***	**0.054**
DenRec	3	1.12	0.34	0.016
SatRec × DenRec	7	0.47	0.86	0.016
SatProv	4	2.27	0.06	0.044
DenProv	3	1.27	0.29	0.019
SatProv × DenProv	5	1.19	0.32	0.029
IES-R (*trauma symptomology screening*)				
SatRec	3	**3.40**	**0.02***	**0.048**
DenRec	3	**3.24**	**0.02***	**0.045**
SatRec × DenRec	7	0.91	0.50	0.03
SatProv	4	0.99	0.41	0.02
DenProv	3	0.85	0.47	0.013
SatProv × DenProv	5	0.47	0.80	0.012

SatRec Satisfaction w/Received Support Relationship, *DenRec* Received Support Network Density, *SatProv* Satisfaction w/Providing Support Relationship, *DenProv* Provided Support Network Density (*$p < .05$)

studies in other locations with an elderly cohort (Lebowitz 2016). In addition, CES-D and IES-R are screening, not diagnostic, instruments. However, the Japanese-language CES-D has high correlations with the diagnostic Hamilton Rating Scale for Depression (Shima et al. 1985). The Japanese IES-R has been used in several 2011-related disaster studies (for example, Saigo et al. 2013; Takahashi et al. 2014; Tsuno et al. 2014).

Conclusion

Research literature on "social capital" posits network density and reciprocity as two important components (Inaba 2005; Son and Lin 2008). Investigating them initially requires validating them from empirical data, which we were able to do. Next is to understand correlation. When reciprocity is operationalized as satisfaction with reciprocal relationships (as an extracted component of satisfaction with receiving and providing support relations), moderate correlation with density was found. Therefore, linking the two variables within a "social capital" construct would appear plausible. However, in our sample interaction between the two variables does not exert effect on mental health outcomes of post-disaster depression and trauma.

This is important for both theoretical and policy reasons. "Social capital" theorists claim the construct responsible for individual wellbeing. However, the lack of interaction effect questions how this occurs; that is, network density for better mental health is not manifested through greater satisfaction from reciprocal support. There are also implications for policies aimed at mitigating mental health impacts of disaster. Past research has implied "higher" social capital societies with "more" perceived reciprocity leads to improved disaster resilience (Wind et al. 2011). The logic of "social capital" suggests greater network density—i.e., having greater aggregates of contacts within networks—will result in greater reciprocity leading to improved mental health. Results from our study do not support this proposition.

Other data here suggest networks are complex constructs concerning support. For example, when examining convergent validity, there was predictor score variance among different relationship categories. This seems to suggest that effects differ depending on network type, confirming Granovetter's belief in differences between inter-group and intra-group network categories (Granovetter 1973). Culture may be one explanation (Inaba et al. 2015). Overall, since benefits from network density on post-disaster mental health are not conferred through greater support reciprocity satisfaction, mechanisms by which strong connections within elderly communities advantage post-disaster mental health require further investigation into the general character of inter-community relations.

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Compliance with Ethical Standards

Conflict of interest The authors declared that they have no conflict of interest.

Ethical Approval All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards.

Appendix 1: Questionnaire Based on Brief Inventory of Social Support Exchange Network (BISSEN) (Aiba et al. 2013, 2017) Tapping Support Source, Emotional or Tangible Support Type, and Providing or Receiving Support Direction

Please circle any specific individuals who come to mind. (Circle as many as necessary)

Support subtype	Question	Support source category					
		Cohabitating family/relative	Other relative	Friend	Neighbor	Colleague	None
Receiving Emotional Support-1	1 Currently is there someone who helps you feel better and listens to your complaints when you are feeling down?	1	2	3	4	5	6
Receiving Emotional Support-2	2 Currently is there someone who you can discuss things with or who can offer you opinions when you have to make a difficult decision?	1	2	3	4	5	6
Receiving Tangible Support-1	3 Currently is there someone who will take up something on your behalf?	1	2	3	4	5	6

Support subtype	Question	Support source category					
		Cohabitating family/relative	Other relative	Friend	Neighbor	Colleague	None
Receiving Tangible Support-2	4 Currently is there someone who would care for you or a family member when physically ill?	1	2	3	4	5	6
Providing Emotional Support-1	5 Currently is there someone whom you help feel better and listen to when they are feeling down?	1	2	3	4	5	6
Providing Emotional Support-2	6 Currently is there someone who can discuss things with you or to whom you offer opinions when they have to make a difficult decision?	1	2	3	4	5	6
Providing Tangible Support-1	7 Currently is there someone for whom you will take up something on their behalf?	1	2	3	4	5	6
Providing Tangible Support-2	8 Currently is there someone or their family you would care for if they were physically ill?	1	2	3	4	5	6

Q1 + Q2 = Received Emotional Network, Q3 + Q4 = Received Tangible Network,
Q1 + Q2 + Q3 + Q4 = Received Total, Q5 + Q6 = Provided Emotional Network, Q7 + Q8 = Provided Tangible Network, Q5 + Q6 + Q7 + Q8 = Provided Total

Appendix 2: Support Source Category Confirmatory Factor Analysis

	1	2	3	4	5	6
Providing emotional support to friends	**0.884**	−0.025	0.017	0.035	0.093	0.125
Providing tangible support to friends	**0.666**	−0.017	−0.05	0.027	−0.058	−0.131
Receiving emotional support from friends	**0.654**	−0.003	0.037	−0.058	0.047	0.007
Receiving tangible support from friends	**0.573**	0.046	−0.021	0.001	−0.02	−0.093
Providing emotional support to colleagues	0.048	**0.915**	−0.009	−0.067	0.032	0.022
Receiving emotional support from colleagues	−0.036	**0.702**	0.036	−0.048	0.009	0.026
Providing tangible support to colleagues	0.013	**0.677**	−0.046	0.039	0.039	−0.027
Receiving tangible support from colleagues	−0.017	**0.574**	0.029	0.083	−0.05	−0.019
Providing tangible support to family	0.002	−0.01	**0.813**	−0.004	0.002	0.004
Receiving tangible support from family	0.101	−0.033	**0.795**	−0.013	−0.08	0.025
Providing emotional support to family	−0.101	0.011	**0.741**	0.029	0.025	−0.028
Receiving emotional support from family	0.009	0.047	**0.705**	−0.01	0.022	−0.009
Providing emotional support to others	−0.061	−0.086	0.042	**0.834**	−0.014	−0.022
Providing tangible support to others	−0.068	−0.056	0.026	**0.831**	0.096	0.034
Receiving emotional support from others	0.077	0.069	−0.051	**0.518**	−0.078	0.063
Receiving tangible support from others	0.032	0.092	−0.015	**0.448**	0.011	−0.078
Providing emotional support to relatives	0.047	−0.018	0.091	0.019	**0.826**	−0.005
Providing tangible support to relatives	0.057	−0.031	−0.023	0.029	**0.788**	−0.026
Receiving tangible support from relatives	0.032	0.046	−0.082	−0.008	**0.698**	−0.035
Receiving emotional support from relatives	−0.051	0.02	−0.011	−0.021	**0.652**	0.017
Providing emotional support to neighbors	−0.013	−0.002	0.014	−0.05	0.014	**−0.842**
Providing tangible support to neighbors	−0.051	−0.019	−0.043	−0.007	0.039	**−0.775**
Receiving tangible support from neighbors	0.045	0.029	−0.002	0.099	0.01	**−0.617**
Receiving emotional support from neighbors	0.067	−0.005	0.036	−0.036	−0.016	**−0.582**
Extraction method: Maximum Likelihood						
Rotation method: Oblimin with Kaiser Normalization						

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