Social Science & Medicine 175 (2017) 58–65

Contents lists available at ScienceDirect

Social Science & Medicine

journal homepage: www.elsevier.com/locate/socscimed

Relation between social network and psychological distress among middle-aged adults in Japan: Evidence from a national longitudinal survey

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ARTICLE INFO

Article history:
Received 7 October 2016
Received in revised form
10 December 2016
Accepted 28 December 2016
Available online 29 December 2016

Keywords:
Social networks
Psychological distress
K6
Main effects model
Stress-buffering model
Longitudinal national survey
Japan

ABSTRACT

It is widely documented that psychological distress is negatively associated with social networks involvement. However, despite the theoretical postulations that social networks are crucial for alleviating psychological distress, no study has yet empirically confirmed the causality of this relationship. Thus, we used the random-effects generalized least squares method to investigate the effect of one- and two-year lagged values for involvement in social networks on psychological distress. Nine years of longitudinal data were extracted from a nationally representative survey in Japan ("The Longitudinal Survey of Middle-aged and Older Persons"). We utilized the Kessler 6 (K6) score to measure psychological distress among 15,242 respondents aged 50–59 years in the baseline year (2005), and stratified participants into three layers of social networks: inner (well-established friendship ties and participating in hobby activates), intermediary (neighborly ties), and outer (involvement in community activities). We found highly significant and negative associations between all three layers and K6 scores, with the strongest association being for the inner layer. We further observed that one-year lagged involvement in the inner and intermediary layers led to significantly lower K6 scores. However, the protective influences of social networks generally diminished over time. In addition, the protective influences of social network involvement on psychological distress were stronger for women than for men. Furthermore, involvement in social networks was especially important for improving mental health among people with psychological distress. These findings would be important for policymaking to prevent mental health deterioration among middle-aged adults in Japan.

1. Introduction

The prevalence of mental disorders has drastically increased during the last decade. Indeed, from 1999 to 2011, the total number of Japanese with mental illness ascended by approximately 1.2 million (from 2.04 to 3.20 million, respectively). Of these individuals, 47.8% were adults aged 35–64 (Ministry of Health, Labour and Welfare, 2016). Worse still, Japan's social attitudes toward mental disorders have been generally unfavorable. According to Ando et al. (2013), only 5% of Japanese believe that mentally ill people can recover from their illness, and 61% of employers claimed that they would never employ someone with a mental illness. Under these circumstances, mental disorders have increasingly become one of the major causes of suicide, which was the second leading cause of death among middle-aged adults in 2012 in Japan (Cabinet Office, 2014). Hence, it is of great interest to determine what factors would be helpful for preventing the deterioration of

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http://dx.doi.org/10.1016/j.socscimed.2016.12.043
0277-9536/

psychological distress among middle-aged adults in Japan.

Western psychologists have clarified several mechanisms for a negative correlation between social networks involvement and psychological distress (Santini et al., 2015). Regarding to people whose mental health being improved, two models—the main effects model and the stress-buffering model—were constructed (Cohen and Wills, 1985; Cohen, 2004; Kawachi and Berkman, 2001). The main effects model posited that involving in social networks would directly improve mental health irrespective of whether people were under distress (Berkman and Glass, 2000). In contrast, the stress-buffering model assumes that involving in social network mitigates distress via modulation of responses to stressful events (Dean and Lin, 1977; Jimmieson et al., 2010; Thoits, 1982). Accordingly, the main effects model reflects a structural aspect of the support from social network, and the stress-buffering model emphasizes on a functional aspect. Meanwhile, psychologists also conceptualized the support from social network in terms of its content and subjectivity (House and Kahn, 1985). Regarding the content, the support was divided to be emotional (e.g., expressions of empathy), instrumental (e.g., tangible aid), and informational (e.g., advice). Regarding the subjectivity, it was characterized to be perceived and received (Wethington and Kessler, 1986). These concepts were not exclusive. For instance, the perceived (received) support from social network was applicable to both the main effect and stress-buffering models, and to each of the content.

While various concepts were established, most empirical studies focused on the subjectivity of support from social network, and explored particularly how perceived support from network involvement reduces physiological distress (Song et al., 2011). Among others, Lin et al. (1999) attempted to incorporate and examine all the above-mentioned concepts. They first distinguished explicitly the structural and functional aspects of the support from social network; then incorporated the perceived and received support, as well as instrumental and emotional support into the functional aspect. Furthermore, they refined the structural aspect by stratifying location of a social network into three layers: outer (e.g., participation in community organizations), intermediary (e.g., connections to colleagues in the workplace), and inner (intimate relations, e.g., friendship ties). Per this framework, each outer layer affords individuals opportunities to build up each inner layer, which leads to a strengthening of the salutary effects of these inner layers on mental health. Lin and colleagues hypothesized that the structural aspect of social network involvement—the three layers—constituted environment in which the functional aspect would be constructed and sustained, and the most inner layer would relate to the strongest functional effect to reduce physiological distress. Their corresponding empirical analyses provided affirmative results.

Asian psychologists also found evidences on the negative correlation between social network involvement and distress (Kim et al., 2008; Liu et al., 1995). Among the literature, Japanese scholars showed that involving in leisure activities was correlated with reduced depressive symptoms among Japanese workers (Wada et al., 2007), and that lack of social activities was correlated with increased depressive symptoms among middle-aged Japanese (Oshio, 2014). Besides, a cross-cultural comparative study by Fiori et al. (2008) revealed that there is no difference in psychological distress between Japanese who were involved in an expansive set of networks and those who were not, but that significant differences do exist for their counterparts in the United States.

Despite these theoretical postulations on how social networks are crucial for improving mental health, this relationship has yet to be confirmed as *causal*. Furthermore, no research in Japan has illustrated how the structural layers of social networks proposed by Lin et al. (1999) protect against psychological distress. A different culture in Japan to that in Western countries makes effect of the three layers, in patricidal that of the outer layer, be ambiguous. In Japan's cultural context, following rules and norms, as well as maintaining group harmony, are more important than satisfying an individual's needs (Taylor et al., 2004). Hence, involving in the outer layer of social network in Japan may not reduce the psychological distress. In fact, the opposite may be the case, and evidences are necessary for the corresponding judgment.

Accordingly, we sought to build on current literature in several respects. First, focusing on the structural aspect of social network, we examine the positive associations between social networks involvement and mental health among middle-aged adults in Japan. Specifically, we stratify social network into the three layers (i.e., outer, intermediary, and inner) to examine its structural effects. Second, we investigate the causal relations between involvement in social networks and mental health by incorporating a one-year lagged value of involvement in each layer as an explanatory variable. Third, we trace the changes in these causal influences over time by further including two-year lagged values of social network involvement. Finally, we verified the applicability of the main effect and stress-buffering models to people in Japan.

2. Methods

2.1. Design and participants

We used longitudinal data over nine consecutive years obtained from a nationally representative survey called “The Longitudinal Survey of Middle-aged and Older Persons” (LSMEP) in Japan, which has been conducted annually since 2005 b y the Ministry of Health, Labour and Welfare (MHLW). The samples for this survey were randomly selected through a two-stage sampling procedure. Specifically, 2515 districts at baseline (i.e., in 2005) were randomly selected from all 5280 districts covered by another nationally representative repeated cross-sectional survey (called the “Comprehensive Survey of Living Conditions”) in 2004. Then, 40,877 respondents were selected randomly from among those aged 50–59 in each selected district in a way that was proportional to the size of the district and the distributions of sex and age in the population.

The self-administered questionnaires were delivered to the 40,877 respondents by enumerators in November 2005; the enumerators successfully retrieved the questionnaires several days later from 34,240 respondents (response rate: 83.8%). For each subsequent year (i.e., from the second year onward), the questionnaires were mailed only to respondents who had responded to the survey within the previous one or two year. No new respondents have been recruited since 2005; the response rate of the latest year—2013—has declined to 58.0% of the total at baseline.

We concentrated on respondents continuously responding to the survey. This ultimately left us with a sample of 15,242 respondents (valid response rate: 44.87%) from year 2005–2013, 7433 of which were men and 7809 women.

2.2. Measurements

2.2.1. Psychological distress

The Kessler 6 (K6) was used to assess psychological distress over each year of the LSMEP (Kessler et al., 2010). This measure comprises six items: “During the past one month (30 days), how much of the time did you feel (1) nervous, (2) hopeless, (3) restless or fidgety, (4) so sad that nothing could cheer you up, (5) that everything was an effort, and (6) worthless?” Response choices ranged from “none of the time” (yielding a score of 0) to “all of the

time" (yielding a score of 4). K6 scores (possible range: 0–24) were derived using the unweighted sum of the six item scores. Higher K6 scores indicate worse mental health status, and respondents with scores of 5 or above were considered to suffer from psychological distress in Japan. This classification for screening mental illness among Japanese has been validated in previous research (Furukawa et al., 2008; Sakurai et al., 2011). We used continuous values of K6 scores, rather than the cutoff point, because we could observe marginal change of K6 score with respect to the social network involvement. The Cronbach's alpha coefficient was 0.897 for the full sample.

2.2.2. Social network

Involvement in social networks was assessed with four dichotomous variables (1 = yes, 0 = no) corresponding to the three layers of social networks (Lin et al., 1999). Specifically, the variables of "having well-established friendship ties" (hereafter, "friendship ties") and "participating in hobby-related activities" ("hobby activities") corresponded to the inner layer. The friendship ties variable reflects some of people's most intimate relations, whereas hobby activities refer to an egocentric perspective on social networks. We measured the intermediary and outer layers of the network using the variables "having certain neighborhood ties" ("neighborly ties") and "participating in community work" ("community work"), respectively. The neighborly ties variable represents slightly weaker relations compared to the abovementioned intimate and egocentric ones, whereas community work (e.g., organizing sport festivals for the community) refers to community involvement; it was considered the farthest layer from the egocentric one.

2.2.3. Demographic, health-related, and socioeconomic background factors

With regard to demographic and health-related background factors, we included marital status (1 = married, 0 = otherwise), age (derived from their birth years and months), gender (1 = men, 0 = women), and suffering from the following diagnoses (1 = yes, 0 = no): diabetes, heart disease, stroke, hypertension, hyperlipidemia, and cancer. For socioeconomic factors, we assessed education level (1 = college graduate or above, 0 = otherwise), providing long-term care to family members (1 = yes, 0 = no), working (1 = yes, 0 = no), house ownership (1 = yes, 0 = no), and monthly income.

2.3. Estimation strategy

We first tested the difference in means of K6 scores between respondents involving and not involving in social networks (i.e. *t*-test), and tested the change in K6 scores from 2005 to 2013 for both respondents. We expected a higher mean of K6 score for respondents who not involving in social networks, and a rising mean for them over time. Furthermore, we employed a random-effects generalized least squares (RE GLS) regression model to investigate the effects of the three layers of social networks on K6 scores. Additionally, we took advantage of the longitudinal nature of the data to include lagged values of social network involvement up to two years before each corresponding year from 2007. We expected two benefits of using such lagged values with longitudinal data. First, we could argue for *causality*—namely, that social networks have a protective effect on psychological distress, given that lagged involvement status would be treated as exogenous to current K6 scores. Second, we could verify whether the protective effects would diminish over time. The regression model used was as follows:

$$y_{it} = \alpha_{0i} + \boldsymbol{\alpha}_1\mathbf{W_{it}} + \boldsymbol{\alpha}_2\mathbf{W_{i,t-1}} + \boldsymbol{\alpha}_3\mathbf{W_{i,t-2}} + \boldsymbol{\alpha}_4\mathbf{X_{it}} + \boldsymbol{\alpha}_5\mathbf{X'_{i,t-1}} + \boldsymbol{\alpha}_6\mathbf{Z_i} + \mu_i + u_{it}, \quad (1)$$

where y_{it} denotes K6 score of respondent i at year t; α_{0i} was the intercept for respondent i; and matrix $\mathbf{W_{it}}$ denotes involvement status in the three layers of social networks for respondent i at year t. Matrices $\mathbf{W_{i,t-1}}$ and $\mathbf{W_{i,t-2}}$ correspond to the one-year and two-year lags of involvement status, while matrix $\mathbf{X_{it}}$ denotes time-variant background factors such as marital status, age, diagnoses, providing long-term care, work status, home ownership, and monthly income. Furthermore, we included one-year lagged values for providing long-term care and work status ($\mathbf{X'_{i,t-1}}$) as explanatory variables. Matrix $\mathbf{Z_i}$ denotes observed time-invariant factors, including gender and education level. Finally, μ_i denotes unobservable time-invariant factors and u_{it} the error term. We assumed $E(\mu_i\mathbf{W}) = E(\mu_i\mathbf{X}) = E(\mu_i\mathbf{Z}) = E(\mu_i u_{it}) = 0$.

Our major concerns were coefficient matrices $\boldsymbol{\alpha}_1$, $\boldsymbol{\alpha}_2$, and $\boldsymbol{\alpha}_3$; we hypothesized that $\boldsymbol{\alpha}_1 < 0$ to confirm the possible negative associations between social networks involvement and K6 scores; we also hypothesized that $\boldsymbol{\alpha}_2 < 0$ and $\boldsymbol{\alpha}_3 < 0$ to confirm the possible protective effects of involving in social networks on reducing K6 scores. With regard to absolute value of each element of the coefficient matrices, we assumed the following:

$$|\alpha_{k,in}| > |\alpha_{k,md}| > |\alpha_{k,out}|, \quad where\ k = 1, 2, 3 \quad (2)$$

We hypothesized that involvement in the inner layer of social networks would have the strongest effect on psychological distress ($\alpha_{k,in}$) compared to involvement in the other two layers; in contrast, the outer layer ($\alpha_{k,out}$) would have the weakest effect, while the intermediary layer ($\alpha_{k,md}$) would be situated somewhere in between the inner and outer ones. Moreover, we expected the absolute magnitudes of these coefficients would be $|\alpha_{1,j}| > |\alpha_{2,j}| > |\alpha_{3,j}|$, where $j = in,\ md,\ out$, thus indicating that the protective effect of each layer would diminish over time.

We conducted the analyses progressively from a simple Model 1 to a comprehensive Model 3. Specifically, Model 1 incorporated only the outer layer of social networks, while Model 2 added the intermediary layer. The full model, Model 3, further included the two variables representing the inner layer. The influence of each outer layer was expected to be diluted after incorporating each inner layer. Based on the Model 3, we further stratified our data by gender. Based on preceding literature, we expected that the protective effects of social networks would be stronger for women than for men. We also stratified the data by the screening cutoff for psychological distress according to K6 scores (i.e., 5 points) to investigate the possible mechanism underlying the relation between social network and psychological distress in Japan. More specifically, the main-effects model would be applicable if the $\boldsymbol{\alpha}$ coefficients are statistically significant for respondents in both K6 score groups; in contrast, the stress-buffering model would be supported if the $\boldsymbol{\alpha}$ coefficients were statistically significant for those whose K6 scores are 5 or above. All estimations were conducted using Stata 14.1.

3. Results

3.1. Basic statistics

Table 1 summarized the K6 scores, involvement in social networks, and background factors between 2005 and 2013. The average K6 score of the full sample was 3.336 (standard deviation (SD) 4.14); women reported higher K6 scores than did men, at 3.514

Table 1
Descriptive statistics of variables over 2005–2013 b y gender.

		N	Full	Men	Women
Outcome Variable:					
Kessler 6 score	M	89,179	3.34	3.11	3.51
	SD		(4.14)	(4.07)	(4.17)
Social Network Factors:					
Friendship ties	%	89,522	81.71	75.29	86.61
Hobby activities	%	86,224	63.68	59.22	67.14
Neighborly ties	%	89,458	67.66	58.53	74.65
Community work	%	86,168	35.13	36.19	34.30
Background Factors:					
Married	%	93,938	85.01	86.11	84.17
Age	M	137,178	59.31	59.47	59.18
	SD		(3.76)	(3.72)	(3.78)
Sex	%	137,178	45.53		
Diagnoses:					
Diabetes	%	81,821	10.34	13.81	7.57
Heart diseases	%	81,732	4.32	6.01	2.96
Stroke	%	81,645	2.12	2.92	1.48
Hypertension	%	81,933	26.97	30.72	23.98
Hyperlipidemia	%	81,666	14.56	14.05	14.97
Cancer	%	81,523	2.71	2.56	2.83
College	%	90,456	14.72	25.19	6.65
Providing long-term care	%	86,964	10.33	7.74	12.33
Work status	%	93,621	66.54	81.14	55.29
Monthly income (1000 yen)	M	46,232	344.84	491.3	191.37
	SD		(922.13)	(1061.02)	(717.96)
House ownership	%	93,466	87.45	86.98	87.82

M: mean; SD: standard deviation.

(SD 4.17) and 3.105 (SD 4.07), respectively. Regarding involvement in social networks, a greater proportion of women were involved in the inner and intermediary layers of social networks than were men. However, a slightly lower proportion was involved in the outer social network.

Table 2 showed the mean K6 scores according to involvement status in each layer of social networks, along with the differences in K6 scores between respondents who had no involvement in networks and those who did. For each layer, we verified that those who were not involved had significantly higher K6 scores. We also found that the difference in K6 scores for the intermediary network layer was larger than that for the outer layer; the largest difference was for friendship ties, one of the inner layer variables.

Table 3 traced the changes in mean K6 scores over time from 2005 to 2013 b y involvement status. Consistent with the results in Table 2, in year 2005, we confirmed higher K6 scores for those were in absence of social network involvement. In year 2013, furthermore, we found significant increases in mean K6 scores for those being out of social network. On the other hand, we did not confirm such significant increase for respondents involved in social networks. Accordingly, the gap of K6 became enlarged from 2005 to 2013, where the largest increase was found for the absence of friendship ties.

The tests in Tables 2 and 3 intuitively verified inferior mental health statuses for respondents who did not involve in corresponding social network, and the disadvantage of mental health was lasting with time. However, the results were derived without control of other important background variables, and thus further investigations using RE GLS method were necessary.

Table 3
Changes in Kessler 6 scores from 2005 to 2013.

	2005		2013		t-test		
	M	SD	M	SD	Diff.		t
Friendship ties							
Yes	2.92	(3.78)	2.91	(3.72)	−0.01		(-0.19)
No	3.96	(4.89)	4.48	(4.98)	0.52	***	(4.49)
Hobby activities							
Yes	2.80	(3.64)	2.76	(3.54)	−0.03		(-0.68)
No	3.53	(4.46)	4.01	(4.71)	0.48	***	(6.26)
Neighborly ties							
Yes	2.88	(3.72)	2.91	(3.70)	0.02		(0.49)
No	3.56	(4.53)	3.84	(4.58)	0.28	***	(3.51)
Community work							
Yes	2.82	(3.63)	2.75	(3.50)	−0.06		(-1.01)
No	3.19	(4.12)	3.54	(4.35)	0.35	***	(6.39)

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

3.2. Effects of the three layers of social networks on psychological distress

Table 4 illustrated the estimation results of the RE GLS method

Table 2
Differences in Kessler 6 scores by social network involvement status.

Layers	Variables	Yes		No		t		
		M	SD	M	SD	Diff.		t
Inner	Friendship ties	3.10	(3.86)	4.36	(4.98)	1.27	***	(49.77)
	Hobby activities	2.94	(3.66)	3.95	(4.67)	1.02	***	(49.57)
Intermediary	Neighborly ties	3.08	(3.84)	3.83	(4.60)	0.75	***	(35.60)
Outer	Community work	2.98	(3.71)	3.48	(4.25)	0.50	***	(24.11)

*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.

Table 4
Effects of social network involvement on Kessler 6 scores using RE GLS regressions.

	Model 1			Model 2			Model 3		
	Coef.	SE	95% CI	Coef.	SE	95% CI	Coef.	SE	95% CI
Current Status:									
Friendship ties							−0.36***	(0.06)	(-0.46, −0.25)
Hobby activities							−0.43***	(0.04)	(-0.51, −0.34)
Neighborly ties				−0.28***	(0.05)	(-0.37, −0.19)	−0.17***	(0.05)	(-0.25, −0.08)
Community work	−0.24***	(0.04)	(-0.31, −0.16)	−0.16***	(0.04)	(-0.23, −0.09)	−0.13***	(0.04)	(-0.20, −0.05)
One-year Lags:									
Friendship ties							−0.22***	(0.06)	(-0.34, −0.11)
Hobby activities							−0.15***	(0.04)	(-0.22, −0.08)
Neighborly ties				−0.21***	(0.04)	(-0.28, −0.14)	−0.13***	(0.04)	(-0.20, −0.05)
Community work	−0.05	(0.04)	(-0.11, 0.01)	0.03	(0.04)	(-0.04, 0.10)	0.05	(0.04)	(-0.02, 0.12)
Two-year Lags:									
Friendship ties							−0.17***	(0.05)	(-0.28, −0.06)
Hobby activities							−0.14***	(0.04)	(-0.24, −0.11)
Neighborly ties				−0.09**	(0.04)	(-0.17, −0.00)	−0.02	(0.04)	(-0.12, 0.08)
Community work	−0.02	(0.04)	(-0.09, 0.05)	0.02	(0.04)	(-0.05, 0.09)	0.04	(0.04)	(-0.03, 0.12)
Married	−0.45***	(0.09)	(-0.66, −0.24)	−0.46***	(0.09)	(-0.61, −0.31)	−0.45***	(0.09)	(-0.62, −0.28)
Age	−0.15***	(0.01)	(-0.17, −0.12)	−0.14***	(0.01)	(-0.16, −0.12)	−0.13***	(0.01)	(-0.16, −0.11)
Gender	−0.29***	(0.06)	(-0.39, −0.19)	−0.38***	(0.06)	(-0.46, −0.30)	−0.53***	(0.06)	(-0.66, −0.39)
College	−0.28***	(0.07)	(-0.41, −0.15)	−0.31***	(0.08)	(-0.44, −0.17)	−0.14*	(0.08)	(-0.28, 0.00)
Diagnoses:									
Diabetes	0.30***	(0.08)	(0.14, 0.46)	0.30***	(0.08)	(0.16, 0.45)	0.29***	(0.08)	(0.12, 0.46)
Heart disease	0.62***	(0.11)	(0.39, 0.84)	0.62***	(0.11)	(0.40, 0.84)	0.61***	(0.11)	(0.39, 0.82)
Stroke	1.13***	(0.22)	(0.69, 1.58)	1.19***	(0.22)	(0.77, 1.61)	1.12***	(0.23)	(0.65, 1.59)
Hypertension	0.16***	(0.05)	(0.06, 0.25)	0.15***	(0.05)	(0.06, 0.24)	0.15***	(0.05)	(0.04, 0.27)
Hyperlipidemia	0.13**	(0.05)	(0.03, 0.23)	0.14**	(0.05)	(0.02, 0.25)	0.17***	(0.05)	(0.05, 0.29)
Cancer	1.38***	(0.16)	(1.04, 1.71)	1.35***	(0.16)	(1.07, 1.62)	1.37***	(0.17)	(1.06, 1.67)
Providing long-term care	0.60***	(0.06)	(0.50, 0.71)	0.58***	(0.06)	(0.45, 0.71)	0.58***	(0.06)	(0.46, 0.70)
Work status	−0.39***	(0.06)	(-0.53, −0.24)	−0.38***	(0.06)	(-0.51, −0.25)	−0.40***	(0.07)	(-0.50, −0.29)
One-year Lags:									
Providing long-term care	0.26***	(0.06)	(0.15, 0.37)	0.27***	(0.06)	(0.16, 0.38)	0.26***	(0.06)	(0.14, 0.38)
Work status	−0.09	(0.06)	(-0.23, 0.05)	−0.10*	(0.06)	(-0.21, 0.01)	−0.09	(0.06)	(-0.22, 0.03)
Income (Logarithm)	−0.06***	(0.02)	(-0.10, −0.03)	−0.07***	(0.02)	(-0.12, −0.02)	−0.07***	(0.02)	(-0.12, −0.01)
House ownership	−0.57***	(0.10)	(-0.75, −0.39)	−0.48***	(0.10)	(-0.66, −0.30)	−0.41***	(0.10)	(-0.60, −0.22)

RE GLS, random-effects generalized least squares method.
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Bootstrap robust standard errors are shown in parentheses, adjusted for clusters in districts. Normal-based 95% confidence intervals, Year dummies from 2008 to 2013 were controlled for in the estimation.

with three models. In Model 1, we found a significant negative association between the outer layer and K6 scores, supporting our hypothesis that involvement in social networks would be negatively correlated with psychological distress. However, we found no evidence that the one- and two-year lagged involvement in the outer layer contributed to better mental health. In Model 2, we confirmed that involvement in the intermediary and outer layers were significantly associated with lower K6 scores. The magnitude of the effect of the intermediary layer was approximately twice that of the outer layer; furthermore, the magnitude of effect of the outer layer effect was considerably reduced from that in Model 1. Considering the lagged values, we found a significant causal relation only between the intermediary layer and psychological distress; that is, having neighborly ties one year before the current year had a significant effect on reducing K6 scores. For the two-year lag, this effect decreased drastically. In Model 3, we found significant negative associations between all layers and K6 scores. Digging deeper, we verified that the inner layer had the strongest association among the three. Furthermore, with insertion of the inner layer variables, the magnitudes of the intermediary and outer layers reduced respectively than them in Model 2.

Concentrating on casual relations, we confirmed that the one year lagged inner and intermediary network involvement led to significantly lower psychological distress. Comparing coefficients on the two year lagged involvements to that on the one year lagged involvements, we found that the effect of the intermediary layer on psychological distress diminished substantially than that of the inner layer.

With regard to the background factors, the results were robust across the models. Specifically, the K6 scores were negatively associated with marriage, and being a college graduate. Men reported lower K6 scores than did women. Suffering from any illness was positively associated with K6 scores. Providing long-term care and working status were positively and negatively associated with K6 scores, respectively. Furthermore, one-year lagged provision of long-term care led to significantly higher K6scores. Finally, income and house ownership were negatively associated with K6 scores. Regarding the significance, the sign, and the magnitude of coefficients, we found consistent results even if we used the cutoff point of K6 scores, and thus the robustness of the results was confirmed.

3.3. Effect of involvement in social networks by gender

Based on Model 3 in Table 4, we also estimated the effects of social network involvement separately by gender (Table 5). Notably, the inner layer was negatively associated with K6 scores for both men and women, where the magnitude of the effect of hobby activities was greater than that of friendship ties. Overall, involving in inner layers were more protective for women than for men. The coefficients for the intermediary and outer layers, however, differed by gender. The intermediary layer being significantly and negatively associated with K6 scores only for men and did the outer layer only for women.

Table 5
Effects of social network involvement on Kessler 6 scores by gender using RE GLS regressions.

	Men			Women		
	Coef.	SE	95% CI	Coef.	SE	95% CI
Current Statuses:						
Friendship ties	−0.32***	(0.07)	(-0.46, −0.18)	−0.44***	(0.10)	(-0.63, −0.26)
Hobby activity	−0.35***	(0.06)	(-0.47, −0.23)	−0.51***	(0.07)	(-0.66, −0.37)
Neighborly ties	−0.23***	(0.06)	(-0.32, −0.13)	−0.09	(0.06)	(-0.21, 0.03)
Community work	−0.09	(0.06)	(-0.23, 0.05)	−0.16***	(0.05)	(-0.26, −0.06)
One-year Lags:						
Friendship ties	−0.27***	(0.07)	(-0.40, −0.13)	−0.17*	(0.09)	(-0.27, −0.03)
Hobby activity	−0.16***	(0.05)	(-0.26, −0.05)	−0.12**	(0.06)	(-0.23, −0.02)
Neighborly ties	−0.10*	(0.06)	(-0.21, 0.01)	−0.06	(0.06)	(-0.28, 0.03)
Community work	−0.06	(0.05)	(-0.04, 0.16)	−0.04	(0.06)	(-0.07, 0.15)
Two-year Lags:						
Friendship ties	−0.17***	(0.06)	(-0.29, −0.04)	−0.18*	(0.09)	(-0.38, −0.02)
Hobby activity	−0.14**	(0.05)	(-0.25, −0.07)	−0.19*	(0.06)	(-0.31, −0.08)
Neighborly ties	−0.03	(0.06)	(-0.14, 0.09)	−0.02	(0.07)	(-0.15, 0.12)
Community work	0.09	(0.06)	(-0.03, 0.12)	0.01	(0.05)	(-0.09, 0.11)

RE GLS, random-effects generalized least squares method.
*$p < 0.1$, **$p < 0.05$, ***$p < 0.01$.
Bootstrap robust standard errors are shown in parentheses, adjusted for clusters in districts. Normal-based 95% confidence intervals, Demographic, health, and socioeconomic factors as well as year dummies from 2008 to 2013 were controlled in the estimation.

Regarding the causal relations, we found that the inner layers led to significantly less physiological distress regardless of gender. For the inner layers, one-year lagged friendship ties and hobby activities led to a reduction in K6 scores for both men and women. Focusing on two-year lagged values, the protective effects of the inner layer networks diminished for men with time, but not for women. For the intermediary layer, one-year lagged neighborhood ties modestly improved mental health for men, but this effect faded completely over time.

3.4. Main effects versus stress-buffering models

We further stratified estimations by the K6 screening cut-off to verify which model—main effects or stress-buffering—governed the relations between social network involvement and mental health in Japan (Table 6). The left panel illustrates the estimations for men and women who were psychologically distressed (K6 $\geq$ 5; full sample: 29.2%, men: 27.1%, women: 30.8%), and the right one illustrates the estimations for those who were not (K6 < 5).

At the first glance, it would appear that, in Japan, the stress-buffering model was more applicable than the main effects model. Focusing on the left panel of Table 6, involvement in the inner-layer social networks was significantly and negatively associated with K6 scores for both men and women under distress. Besides, involving in the intermediary and outer layers was also negatively associated with K6 scores for women suffering from distress. The associations, overall, were stronger for women than for men. For the causal relationships, only inner layer involvements significantly reduced K6 scores regardless of gender. The effect of having friendship diminished over time for men, whereas it was lasting among women. On the other side, the intermediary and outer layers did not shed significant impact on mental health improvement for men and women under distress.

Turning to the right panel of Table 6 and focusing on people not suffering from distress, only the inner layer involvements reported negative associations. However, the associations were inconsistent by gender; that is, having friendship ties associated with lower K6 only for men, and joining hobby activity, despite moderately, did only for women. However, there was no significant evidence for causal relationships like that in the left panel, neither for men nor for women.

4. Discussion

The negative correlation between social network and psychological distress has been widely documented in past literature (Santini et al., 2015; Szreter and Woolcock, 2004). In the present study, we build on the validity of these observations by implementing the RE GLS method with nationally representative longitudinal data (2005–2013) from middle-aged people in Japan. By stratifying social networks into three layers (inner, intermediary, and outer) and including one-year and two-year lagged involvement in each corresponding layer, we confirmed the following: (1) *all* layers of social networks were significantly and highly negatively associated with K6 scores; (2) the strongest association was between the inner layer and K6 scores, while the weakest association was between the outer layer and K6 scores; (3) the associations were generally stronger among women than men; (4) involving in the inner and intermediary layers of social networks led to significantly lower K6 scores, while no clear causal relation was found for the outer layer; (5) the protective effects of the inner and intermediary layers on mental health diminished over time for men, but seemed to strengthen for women (in particular the effect of the inner layer); and (6) taking both association and causality into account, the stress-buffering model appears to be most applicable in Japan for understanding the relations between social networks and psychological distress.

The findings (1) is in line with previous research in Western countries showing positive associations between social networks and mental health (Fiori et al., 2006; Giurgescu et al., 2015; Kawachi and Berkman, 2001; Pachucki et al., 2015). Furthermore, despite the different specifications of the network layers, finding (2) was, as expected, consistent with that of the original study (Lin et al., 1999) in terms of the significance and magnitude of the associations between each layer and psychological distress. Specifically, it is found that maintaining emotionally intimate relationships (e.g., friendship ties) and involving in networks that satisfy the ego (e.g., hobby activities) had the strongest, most sustained effects on reducing psychological distress. Neighborly ties—representing the intermediary layer of social networks—also contributed to improve mental health, but the effects of this layer were somewhat weaker than were those of the inner layer and faded moderately over time. Although the outer layer was negatively associated with psychological distress, it did not appear to have a direct effect on mental

Table 6
Effects of social network involvement on Kessler 6 (K6) scores by K6 screening cutoff and gender using RE GLS regressions.

	K6 ≥ 5						K6 < 5					
	Men			Women			Men			Women		
	Coef.	SE	95% CI	Coef.	SE	95% CI	Coef.	SE	95% CI	Coef.	SE	95% CI
Current Statuses:												
Friendship ties	-0.25^{*}	(0.13)	(-0.52, 0.02)	-0.43^{***}	(0.16)	(-0.71, −0.14)	-0.08^{***}	(0.03)	(-0.14, −0.02)	−0.03	(0.04)	(-0.13, 0.07)
Hobby activity	-0.54^{***}	(0.12)	(-0.76, −0.31)	-0.58^{***}	(0.11)	(-0.80, −0.35)	0.02	(0.03)	(-0.02, 0.06)	-0.06^{*}	(0.03)	(-0.13, 0.01)
Neighborly ties	−0.19	(0.13)	(-0.45, 0.07)	-0.24^{*}	(0.13)	(-0.49, 0.01)	−0.03	(0.03)	(-0.09, 0.02)	−0.04	(0.03)	(-0.10, 0.02)
Community work	−0.15	(0.14)	(-0.37, 0.07)	-0.22^{**}	(0.11)	(-0.41, −0.02)	0.04	(0.03)	(-0.03, 0.10)	−0.01	(0.03)	(-0.06, 0.04)
One-year Lags:												
Friendship ties	-0.26^{**}	(0.13)	(-0.56, 0.03)	-0.27^{*}	(0.16)	(-0.62, 0.04)	−0.01	(0.03)	(-0.06, 0.05)	−0.06	(0.05)	(-0.16, 0.05)
Hobby activity	-0.15^{*}	(0.11)	(-0.39, −0.01)	-0.10^{*}	(0.11)	(-0.30, 0.01)	0.03	(0.03)	(-0.02, 0.08)	−0.02	(0.03)	(-0.10, 0.05)
Neighborly ties	−0.16	(0.12)	(-0.39, 0.07)	−0.16	(0.13)	(-0.42, 0.11)	−0.02	(0.03)	(-0.07, 0.03)	0.01	(0.03)	(-0.05, 0.07)
Community work	0.02	(0.12)	(-0.23, 0.28)	0.02	(0.11)	(-0.17, 0.22)	0.01	(0.03)	(-0.04, 0.06)	0.02	(0.03)	(-0.04, 0.08)
Two-year Lags:												
Friendship ties	-0.24^{**}	(0.13)	(-0.52, −0.03)	-0.27^{*}	(0.18)	(-0.60, 0.01)	−0.02	(0.03)	(-0.09, 0.05)	−0.03	(0.04)	(-0.12, 0.06)
Hobby activity	−0.29	(0.11)	(-0.48, 0.10)	0.01	(0.12)	(-0.12, 0.31)	−0.02	(0.03)	(-0.08, 0.04)	0.01	(0.03)	(-0.05, 0.06)
Neighborly ties	0.15	(0.13)	(-0.09, 0.40)	−0.21	(0.14)	(-0.49, 0.07)	−0.05	(0.03)	(-0.11, 0.01)	0.00	(0.03)	(-0.08, 0.08)
Community work	0.21	(0.14)	(-0.06, 0.49)	0.00	(0.11)	(-0.18, 0.18)	0.07	(0.03)	(0.02, 0.11)	−0.03	(0.03)	(-0.09, 0.03)

RE GLS, random-effects generalized least squares method.
$^{*}p < 0.1$, $^{**}p < 0.05$, $^{***}p < 0.01$.
Bootstrap robust standard errors are shown in parentheses, adjusted for clusters in districts. Normal-based 95% confidence intervals. Demographic, health, and socioeconomic factors as well as year dummies from 2008 to 2013 were controlled in the estimation.

health improvement, given that neither of the corresponding lags had a significant effect on psychological distress in any of the models in Table 4.

Finding (3), moreover, updates the original findings by delineating gender differences. Japanese middle-aged women are more likely to have inner layer involvement. In our research, the proportions of women involving in inner layers are higher than that of men by about 10% points (Table 1). Furthermore, the negative association between the inner layer and K6 scores is also stronger for Japanese women than the one for men. These findings could be explained by cultural characteristics in Japanese society such that it is culturally more acceptable for Japanese women to express emotion within intimate relations than it is for men, and thus women comparatively obtain stronger support from these relations (Belle, 1987; Flaherty and Richman, 1989; Kawachi and Berkman, 2001). Besides, it is found that women are more likely to mobilize support from diverse social networks more frequently compared to men who tend to focus on conjugal relations and rely exclusively on their spouses (Antonucci and Akiyama, 1987; Fu and Noguchi, 2016). This is supported by our findings as well, where the inner and outer layers of social networks are simultaneously linked to lower psychological distress.

Finding (4) revealed that having friends and joining in hobby activities lead to better mental health among middle-aged adults in Japan; in contrast, being involved in community work has no clear benefits. Most of the community works in Japan (e.g., cleaning fallen leaves in central parks or organizing sports festivals) are, to some extent, obligatory. Japan's culture of interpersonal harmony disapproves of extreme choices in all aspects of social life, which can make it difficult for individuals to say no to invitations to join in community works (Kitayama et al., 2000; Triandis, 2001). In the short term, becoming involved in community work may be positively associated with mental health, as people would make acquaintances during such work; in the long term, however, the burden of obligatory work might overwhelm the benefits and thereby lead to psychological distress. In contrast, friendship ties and hobby activities, considered to belong to the inner layer of networks, are optional and voluntary (Antonucci and Akiyama, 1995). In sum, companionship provided by friends and self-fulfillment obtained from hobby activities appear to most effectively improve mental health in both the short and the long term.

Finding (5) illustrates how the protective effects of social networks for psychological distress change over time by gender. Interestingly, the protective effect of the inner layer weakens for men but appears to strengthen for women. Combining with Finding (3), discussed earlier, we posit that gender inequality in the protective effect of the inner layer on mental health might grow over time in Japan. Put another way, the advantage of support from intimate relations for women might be enhanced with time, whereas it may work in the opposite way for men. This may reflect the fact that with the deepening of relations, women may increasingly rely on companions within their networks.

Finding (6) illustrates the importance of the stress-buffering model to explaining the protective effect of social networks in Japan. This is consistent with preceding research in Western countries (Cohen and Wills, 1985; Jimmieson et al., 2010; Kawachi and Berkman, 2001; Mossakowski and Zhang, 2014). It appears that involvement in social networks (in particular the inner layer) might help Japanese middle-aged adults suffering from psychological distress modulate their responses to stressful events, which in turn protects them against worsening of such distress. Regarding the finding, however, we shall notice that social network helps people under stress only if they got involved into the network; whereas people suffering from distress are found be less likely to join social networks (Achterberg et al., 2003). Taking the Japan's unfavorable

social settings regarding mental disordered people into consideration, we suggest government to encourage people under distress to involve more frequently into social networks that may effectively prevent deterioration of mental health.

The current study suffers several limitations. First, we could not control for unobservable individual factors that might correlate with both psychological distress and social network involvement. A well-known example would be introversion, an individual personality trait that is considered unobservable, which might be simultaneously associated with less social network involvement and lower psychological distress. In addition, we do not consider respondents quitting the survey, mental health of whom might be worse than those continuously responding to the questionnaires. Thus, our findings might overestimate the effects of social network involvement on mental health. Second, due to the data limitation, we do not measure the functional aspect of support from social network as Lin and colleagues did. Also, we cannot rule out the possibility of measurement error, as our data are collected from self-reported and retrospective surveys. Further, we do not consider dynamic process of mental health, that is, we do not include lagged K6 scores as one explanatory variable. The reason is that after using the dynamic panel data (DPD) model to control endogeneity issue raising from lagged K6, we find the effects of social network involvement are not statistical different to that in our initial model. In fact, by implementing DPD model, we confirm the robustness of our findings. Similarly, we do not consider the bidirectional relation between the social network and mental health, which is well documented in literature utilizing cross-lagged panel method (Kenny, 1975). Finally, we compare and distinguish our findings to literature in Western countries, but not to that in other Asian countries; discussions are accordingly limited. These issues should be discussed and addressed in future investigations.

In conclusion, this study suggests that involvement in social networks leads to less psychological distress among middle-aged adults in Japan. Moreover, involvement in the inner layer of social networks had the strongest effect. These findings could be useful for preventing mental health deterioration among middle-aged adults in Japan, and further research with comprehensive measurements of social support and social capital should be necessary to obtain a deeper understanding of their relations to mental health.

Acknowledgement

This study was financially supported by Research on Policy Planning and Evaluation (H27-Seisaku-Senryaku-012) under the aegis of the MHLW (PI: Prof. Nanako Tamiya at Tsukuba University). This research project has received official ethic approval to use the secondary data from the Statistics and Information Department of the MHLW under Tohatsu-1218-1 as of December 18, 2015.

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Geriatrics Gerontology INTERNATIONAL Medline Indexed

Geriatr Gerontol Int 2017

ORIGINAL ARTICLE: EPIDEMIOLOGY, CLINICAL PRACTICE AND HEALTH

Impact of long-hours family caregiving on non-fatal coronary heart disease risk in middle-aged people: Results from a longitudinal nationwide survey in Japan

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Aim: The effects of family caregiving, especially long-hours caregiving, on coronary heart disease (CHD) are debatable. We examined the impact of family caregiving on incident non-fatal CHD.

Methods: We used data from the Longitudinal Survey of Middle-Aged and Elderly Persons from 2005 to 2010, a nationwide panel survey for Japanese people aged 50–59 years in 2005 (baseline). After we excluded non-respondents and people with missing key variables at baseline, 25 121 individuals without CHD, stroke or cancer were followed up for a mean of 4.6 years. The exposure was assessed at baseline by three indicators: (i) family caregiving; (ii) hours spent caregiving; and (iii) kinship type of care recipient. The non-fatal CHD incidence was identified according to questionnaire responses from 2006 to 2010.

Results: Cox's proportional hazards analysis did not show a statistically significant association between family caregiving and incident non-fatal CHD (hazard ratio [HR] 1.13, 95% confidence interval [CI] 0.92–1.40). Caregivers who spent 20–69 h per week on care showed a statistically significant increased risk for non-fatal CHD (HR 1.78, 95% CI 1.23–2.58) compared with non-caregivers; whereas this increased risk was statistically significant only among women (HR 1.98, 95% CI 1.27–3.08), but not among men (HR 1.35, 95% CI 0.67–2.71). Kinship type of care recipient did not make a significant difference to the effects of family caregiving on incident non-fatal CHD.

Conclusions: Long-hours family caregiving could be an independent risk factor for incident non-fatal CHD among middle-aged women in Japan. **Geriatr Gerontol Int 2017; ••: ••–••.**

Keywords: caregivers, coronary heart disease, epidemiology, family care, Japan.

Introduction

The need for care for disabled and elderly people is growing in aging societies. As a result, informal care – provided mainly by non-professional family members, other relatives or friends – is playing an increasingly important role.[1] In Japan, for example, whose population is aging faster than those of any other countries,[2] family members accounted for approximately 70% of main caregivers for persons requiring long-term care, amounting to 5 million people in 2010.[3] Such family care is physically and psychologically demanding for caregivers.[4] It has thus been suggested that caregiving could be a significant risk factor for caregivers' health.[5] Determining the effects of family caregiving on caregivers' health is particularly important, because their own health problems can cause them not only to suffer from a heavier caregiving burden, but also to discontinue employment or family care.

Previous studies have identified an association between family caregiving and increasing psychological problems.[6,7] The effects of family caregiving on mortality are inconclusive. One study carried out in the 1990s showed that caregiving could be associated with higher mortality.[8] Conversely, recent large-population studies have suggested that caregiving might decrease mortality, and that family care could exert positive effects.[9,10]

Accepted for publication 20 February 2017.

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doi: 10.1111/ggi.13061

The effect of family caregiving is likewise debatable with respect to coronary heart disease (CHD). In a study using the Nurses' Health Study cohort in the USA, family caregiving for a spouse for ≥9 h/week was associated with increased incident CHD.[11] Overexertion, physical effects of psychological stress, decreased self-care and unhealthy lifestyles presumably explain this association.[5] After controlling for the health status at baseline, another study, using the Whitehall II cohort, found that caregiving per se was not associated with a higher risk of CHD.[12] However, those studies did not focus on long-hours care. Long-hours caregiving, such as ≥20 h/week devoted to caregiving, is very common in developed countries.[13] However, no firm conclusions have been drawn about the effects of long-hours caregiving on CHD. By contrast, the effects of long-hours working on CHD have been rigorously examined – and indeed, almost confirmed.[14]

Using a Japanese nationwide panel study for the middle-aged population, in the present study we investigated the effect of family caregiving on CHD incidence in terms of the number of care hours. A previous study showed that the kinship type of care recipient could impact the effect of caregiving on CHD;[11] thus, we also examined caregiving effects with respect to the category of recipients.

Methods

Data collection

In the present observational longitudinal study, we extracted the data from the Longitudinal Survey of Middle-Aged and Elderly Persons, which is a Japanese nationwide population-based panel survey. The Japanese Ministry of Health, Labor and Welfare has carried out this survey every year since 2005. From the data obtained in this survey, we used six waves of panel data. The individuals in the first wave were aged 50–59 years, and the data were collected nationwide in November 2005 through a two-stage random sampling procedure. Questionnaires were distributed to the participants' homes by investigators or mail in late October; the questionnaires were to be completed by 2 November, and returned to the investigators directly or by mail several days later. The questionnaires were distributed to 40 807 individuals, and 34 505 responded (response rate 84.6%). The second to sixth waves of the survey, which targeted the participants who responded at least once in the past 2 years, were carried out in early November every year from 2006 to 2010. The numbers of respondents in the panel surveys from 2006 to 2010 were 32 285, 30 730, 29 605, 28 736 and 26 220, respectively. Of 34 505 respondents in the first wave, we excluded 7970 owing to missing key variables with respect to health behavior, disease information and socioeconomic factors at baseline (the first wave in 2005). There were no remarkable differences in age and sex between individuals with and without missing key variables (the mean ages were, respectively, 54.9 and 54.6 years; women accounted for 51.6% and 51.4%). Among the remaining 26 535 participants, we excluded 1414 because they had CHD, stroke or cancer at baseline. Accordingly, 25 121 participants were analyzed. Based on the second to sixth waves of the survey, we identified either incident CHD or the dropout. The institutional review board of The University of Tokyo approved this study protocol after ethical consideration (approval no. 11033).

Measures

Caregiving status

The explanatory variable in the present study was caregiving status at the baseline. We assessed caregiving status by the following three indicators: (i) family caregiving; (ii) hours spent on caregiving; and (iii) relationship of the care recipient to the participant. Family caregiving was represented as a dichotomous variable according to the answer (yes, 1; no, 0) to the question of "Are you currently caring for any relatives regardless of whether they are within or out of the household?" The hours spent on caregiving were measured by the average hours spent on caregiving per week in the previous month. Then, we categorized the average hours into three levels: ≤9 h/week; 10–19 h/week; and 20–69 h/week. In one official Japanese survey, sleeping and work (paid work or housework) were found to occupy approximately 14 h a day on average among caregivers.[15] Therefore, we excluded caregivers who responded that they had spent 70 h/week or more on care. Such caregivers accounted for approximately 4% of the total. The relationship of the care recipient to the participant was categorized as parent, spouse's parent or other. We did so because among Japanese aged in their 50s, most care recipients are parents or spouse's parents (see Discussion). Participants categorized as both "caring for parents" and "caring for parents-in-law" were excluded from the analysis.

Incident CHD

In the questionnaire, participants were asked every year if they had been diagnosed as having heart disease (myocardial infarction or angina pectoris) in the previous year. If the response was yes, the individuals were identified as having CHD. We regarded the onset year of CHD as the year when individuals first reported CHD diagnosis. As we could not identify death in our data, we only observed non-fatal CHD, which is often regarded as a clinically important indicator for mortality.[16]

Covariates

The covariates included age; sex; marital status; academic background; employment status; heavy alcohol consumption; smoking status (current or past smoking);

exercise habits; current status of diabetes, dyslipidemia and hypertension; and depressive states. These variables were derived from the first-wave data; only academic background was derived from second-wave data, because it was first included at that time. Marital status was represented as whether the individual cohabited with their spouse. We classified academic background as whether the participant had attended university or graduate school. We defined heavy alcohol consumption as ethanol intake of more than 300 g/week,[17] and exercise habits in terms of doing moderate to high-level exercise twice or more a week. We identified the current status of diabetes, dyslipidemia and hypertension through self-reporting to the questions that asked if they were diagnosed with such diseases or under medical treatment at the time. We determined depressive states using the Kessler Psychological Distress Scale at baseline, and we considered the Kessler Psychological Distress Scale scores >12 as a proxy for depressive states.[18]

Statistical analysis

We compared the characteristics at baseline between non-caregivers and caregivers. The incidence rate of CHD was estimated for three family caregiving indicators. We applied Cox's proportional hazards model to assess the associations of three indicators with risk of CHD. Individuals' health status, health behaviors, and employment status would be potential confounders in the relationship between caregiving and incident CHD,[12] whereas caregiving might lead to the CHD incidence through deterioration in health status or health behaviors and unemployment.[5] For each indicator, hence, we used two types of models; in model 1, we adjusted for age; sex; marital status; academic background at baseline, and in Model 2, we additionally adjusted for the following variables that could be mediators: job status; heavy alcohol consumption; smoking status; exercise habits; current status of diabetes, dyslipidemia and hypertension; and depressive states at baseline. We regarded participants as dropouts when they did not respond to the questionnaires for the first time from the first wave. We carried out two robustness checks. First, we applied more segmentalized criteria (0–4 h/week, 5–9 h/week, 10–19 h/week, 20–49 h/week, 50–69 h/week) in line with previous research.[19] Second, we repeated the analysis by changing the upper limit of the inclusion threshold of the hours spent on family care from 70 h/week (main analysis), to 100 h/week, 140 h/week and no upper threshold, respectively. We carried out all analyses using Stata version 14 (StataCorp, College Station, TX, USA).

Results

Table 1 reports the characteristics of participants stratified by caregiving status at baseline. Compared with non-caregivers, caregivers tended to be women, unemployed, unmarried and somewhat older. Smoking habits and some alcohol consumption were more frequent among non-caregivers than among caregivers. Table 2 shows non-fatal CHD incidence by family caregiving status. Over 5-year follow up, we recorded 1083 cases of non-fatal CHD (98 among caregivers, 985 among non-caregivers). We observed 4598 dropouts (331 among caregivers, 4267 among non-caregivers). The average follow-up period was 4.6 years. Caregivers had a little higher incidence rate of non-fatal CHD than non-caregivers; caregivers spending 20–69 h on care had a much higher incidence rate than non-caregivers (16.1 *vs* 9.6 /1000 person-years).

Table 3 shows the association between caregiving status and incident non-fatal CHD. Cox's proportional hazards analysis adjusted for age, sex, marital status, and academic background did not show a statistically significant association between family caregiving and incident non-fatal CHD (model 1: hazard ratio [HR] 1.15, 95% confident interval [CI] 0.93–1.42). When further adjusted for other confounders, it remained insignificant (model 2: HR 1.13, 95% CI 0.92–1.40). Regarding care hours, both in model 1 and model 2, caregivers spending 20–69 h/week on family care showed a greater risk for incident non-fatal CHD (model 1: HR 1.88, 95% CI 1.30–2.73; model 2: HR 1.78, 95% CI 1.23–2.58), though caregivers spending ≤9 h or 10–19 h/week did not have a significantly increased risk. The relationship to the care recipient was unlikely to be associated with incident non-fatal CHD both in model 1 and model 2.

In the analyses stratified by sex (Table 4), family care for ≤9 h or 10–19 h/week did not have a significant effect on CHD both in model 1 and model 2. Caregiving for 20–69 h/week was likely to increase the incidence of non-fatal CHD compared with non-caregivers for women (model 1: HR 2.10, 95% CI 1.35–3.26; model 2: HR 1.98, 95% CI 1.27–3.08); however, there was no statistically significant association for men (model 1: HR 1.43, 95% CI 0.71–2.88; model 2: HR 1.35, 95% CI 0.67–2.71). There was no evidence of a statistically significant interaction between sex and care hours. For both sexes, the relationship to the care recipients did not affect the incidence of non-fatal CHD.

In the first robustness check, the effects of family caregiving were unremarkable in the categories under 20 h/week; but there was a notable increase for 20–49 h/week and 50–69 h/week. In the second robustness check, when we considered the participants who reported unrealistically long hours of family care, whichever upper threshold we applied, the results did not change greatly.

Discussion

Using Japanese nationwide panel data for the middle-aged population, in the present we investigated the association

Table 1 Baseline characteristics and comparison between caregivers and non-caregivers

	Non-caregivers (*n* = 23 021)		Caregivers (*n* = 2100)	
	n	%	*n*	%
Age (years)				
50–54	10 976	47.7	913	43.5
55–59	12 045	52.3	1187	56.5
Sex				
Men	11 351	49.3	729	34.7
Women	11 670	50.7	1371	65.3
Lifestyle-related diseases				
Diabetes	1515	6.6	115	5.5
Dyslipidemia	2030	8.8	241	11.5
Hypertension	3839	16.7	354	16.9
Kessler 6 score				
–4	17 362	75.4	1 332	63.4
5–12	5 072	22.0	677	32.2
≥13	587	2.5	91	4.3
Smoking status				
Never smoking	11 021	47.9	1265	60.2
Past smoking	5001	21.7	365	17.4
Current smoking	6999	30.4	470	22.4
Alcohol consumption				
Non-drinker	11 045	48.0	1158	55.1
Ethanol intake of <300 g/week	11 053	48.0	874	41.6
Ethanol intake of ≥300 g/week	923	4.0	68	3.2
Moderate-to-hard exercise				
No	15 643	68.0	1 359	64.7
1/month–1/week	2814	12.2	261	12.4
≥2/week	4564	19.8	480	22.9
Academic background				
Junior high school	3914	17.0	244	11.6
High school	11 413	49.6	1037	49.4
College	3637	15.8	441	21.0
University/graduate school	3916	17.0	372	17.7
Others	141	0.6	6	0.3
Marital status				
Married	19 554	84.9	1756	83.6
Separated/divorced/widowed	2338	10.2	196	9.3
Never married	1129	4.9	148	7.0
Employment				
Employed	18 979	82.4	1511	72.0
Not employed	4042	17.6	589	28.0

Kessler 6 score: Kessler Psychological Distress Scale score. Moderate-to-hard exercise was identified as panting exercise (e.g. walking, jogging, swimming, aerobics). Ethanol intake of 300 g/week was identified as "3 days/week and 100 g/drinking" or "5 days/week and 60 g/drinking." College included junior/vocational/technical colleges.

between family caregiving and incident CHD. After adjusting for potential confounders, we did not find a clear association between family caregiving and incident CHD. However, regarding caregiving burden, longer hours of family care (20–69 h/week) were an independent risk factor for incident non-fatal CHD. An investigation by Lee *et al.* using the Nurses' Health Study showed that family caregiving of more than 9 h/week for a spouse resulted in a higher risk of CHD; however, that finding has limited external validity, because the participants were

Table 2 Non-fatal coronary heart disease incidence stratified by family caregiving status

Exposure	Number in category	Person-years at risk	Case with non-fatal CHD	Incidence rate (/1000 person-years)
Family caregiving (no)	23 021	103 117	985	9.6
Family caregiving (yes)	2100	9507	98	10.3
Care hours of family caregivers				
≤9 h/week	1048	4802	42	8.7
10–19 h/week	340	1541	14	9.1
20–69 h/week	401	1805	29	16.1
Care recipients of family caregivers				
Caring for the parent	1199	5367	61	11.4
Caring for the parent-in-law	666	3089	29	9.4
Caring others	176	770	7	9.1

In the category of care hours, we excluded 221 caregivers who did not respond about the number of care hours; 90 caregivers who replied that they had spent ≥70 h on care were excluded. In the category of care recipients, 59 individuals who cared for both parents and parents-in-law were excluded.

Table 3 Association between family caregiving status and incident non-fatal coronary heart disease

Exposure	Hazard ratio (95% CI)	
	Model 1	Model 2
Family caregiving status		
Family caregiving (yes)†	1.15 (0.93–1.42)	1.13 (0.92–1.40)
Care hours		
≤9 h/week†	0.96 (0.70–1.30)	0.97 (0.71–1.32)
10–19 h/week†	1.04 (0.62–1.77)	1.04 (0.61–1.77)
20–69 h/week†	1.88 (1.30–2.73)	1.78 (1.23–2.58)
Care recipients		
Caring the parent†	1.17 (0.90–1.52)	1.16 (0.90–1.51)
Caring the parent-in-law†	1.22 (0.84–1.77)	1.22 (0.84–1.77)
Caring others†	1.00 (0.48–2.11)	0.91 (0.43–1.93)

In the model using the categorization by care hours as an exposure, we excluded 221 caregivers who did not respond about the number of care hours; 90 caregivers who replied that they had spent ≥70 h on care were excluded. In the model using the categorization by care recipients as an exposure, 59 individuals who cared for both parents and parents-in-law were excluded from analysis. †Reference category for each exposure was no family caregiving. In model 1, we adjusted for age; sex; marital status; and academic background at baseline. In model 2, we additionally adjusted for job status; heavy alcohol consumption; smoking status; exercise habits; current status of diabetes, dyslipidemia and hypertension; and depressive states at baseline. CI, confidence interval.

female medical care professionals.[11] The results of the present study, therefore, reinforce those of Lee *et al.* The present finding suggests, therefore, the necessity of interventions to prevent the development of CHD associated with long hours of family caregiving.

Thus far, the biological association between family caregiving and CHD has not been sufficiently clarified. It has been shown that heavy physical activity and emotional stress are acute risk factors for incident CHD by triggering sympathetic nerve systems.[20] Family caregiving is generally considered to be involved with physical or psychological stress.[21] These findings suggest that family caregiving has immediate negative effects on the cardiovascular system. From this perspective, longer-hours caregiving, which leads to a greater caregiving burden, could lead to a higher frequency of CHD development.[21] In addition to this short-term mechanism, long-term mechanisms have been suggested. Consistent family care can lead directly to deterioration in the caregivers' lifestyle, as well as having indirect effects in terms of psychiatric stress.[4,22] From this perspective, model 2 (fully adjusted model) might suffer from overadjustment, though the results in model 1 (minimally-adjusted model) were quite similar to those in model 2. Even if health status at baseline, along with health behaviors and job status, was a mediator, our full-adjusted model showed that long hours of family caregiving per se could be an independent and direct risk

Table 4 Association between family caregiving status and incident non-fatal coronary heart disease stratified by sex

Exposure	Men Hazard ratio (95% CI)		Women Hazard ratio (95% CI)	
	Model 1	Model 2	Model 1	Model 2
Family caregiving status				
Family caregiving (yes)†	1.07 (0.78–1.46)	1.06 (0.78–1.45)	1.22 (0.92–1.62)	1.18 (0.89–1.57)
Care hours				
≤9 h/week†	1.04 (0.69–1.56)	1.06 (0.70–1.59)	0.88 (0.55–1.41)	0.87 (0.54–1.40)
10–19 h/week†	1.25 (0.59–2.65)	1.27 (0.60–2.68)	0.87 (0.41–1.83)	0.86 (0.41–1.82)
20–69 h/week†	1.43 (0.71–2.88)	1.35 (0.67–2.71)	2.10 (1.35–3.26)	1.98 (1.27–3.08)
Care recipients				
Caring for the parent†	1.09 (0.77–1.54)	1.08 (0.76–1.53)	1.30 (0.88–1.92)	1.29 (0.87–1.91)
Caring for the parent-in-law†	1.23 (0.55–2.75)	1.28 (0.57–2.87)	1.20 (0.78–1.83)	1.17 (0.77–1.79)
Caring for others†	0.87 (0.28–2.72)	0.82 (0.26–2.55)	1.12 (0.42–3.00)	1.04 (0.39–2.79)

In the model using the categorization by care hours as an exposure, we excluded 221 caregivers who did not respond about the number of care hours; 90 caregivers who replied that they had spent ≥70 h on care were excluded. In the model using the categorization by care recipients as an exposure, 59 individuals who cared for both parents and parents-in-law were excluded from analysis. †Reference category for each exposure was non-caregivers. CI, confidence interval.

factor for CHD. This finding was in contrast to the study carried out by Buyck *et al.*, which concluded that family caregiving itself did not have an impact on CHD after adjusted for health status at baseline.[12]

In contrast, some recent studies have shown that caregivers have lower mortality.[9,10] This phenomenon is considered to be a result of the positive effects of family caregiving: caregivers find their role satisfying and rewarding; alternatively, caregivers are generally more active than non-caregivers.[23,24] Even if there were such protective effects, the present results showed the longer-hours caregiving would counteract such effects.

Our stratified analyses show that the effects of long hours of family care on incident CHD were observed only among women, not among men. This finding could be partly due to the fact that some kinds of care work (e.g. transfer aid, excretion care and bathing assistance) can be physically demanding for women owing to low muscle strength. Combined with the finding that female caregivers tend to suffer more greatly with the care burden and become more depressive than males, female caregivers might be psychologically and physically negatively affected by family caregiving.[25,26] Nevertheless, because there was no significant interaction between sex and care hours, it was unclear if the effects of long hours of family care differed by sex. Further studies with more participants than the present study might reveal the impact of long-hours care among men and its sex difference.

Some limitations should be noted. First, the outcome in the present study was non-fatal CHD. We could not assess the relationship between family caregiving and fatal CHD. According to the Japanese vital statistics (2011), however, as the number of fatal CHD is much smaller than that of non-fatal CHD among this study's age group (<1 individual per 1000 person-years), the present results would closely represent the effects of family caregiving on all CHD incidence.[27] Second, we did not use clinical data or physicians' diagnoses; we used self-reporting to identify the incidence of CHD. We could not distinguish stable angina pectoris from acute coronary syndrome. In the present study, the incident rate of CHD was 9.4 individuals per 1000 person-years. This value is similar to the incident rate of CHD (acute coronary syndrome and stable angina pectoris) in a middle-aged population.[28,29] Third, family caregiving status at baseline and covariates were assessed in the same self-administered questionnaire. This might lead to dependent errors among exposure variables and covariates, and generate some distortion. Fourth, the relatively high rate of dropout (18%) might cause selection bias. Fifth, the present study did not consider either of formal care utilization or care recipients' states, such as clinical information, degree of need for care and details of care; however, these factors could potentially alter the family care burden, and accordingly, could potentially modify the effects of family care on the incident CHD. Further investigations of the health impacts of both informal and formal care in the context of care recipients' states are required.

The necessity of care for elderly or disabled people is increasing worldwide along with global aging, though the provision of formal care is restricted by financial constraints. Family care plays an important role in care systems;[30] accordingly, the effect of family caregiving on physical health is gaining attention. In the present population-based study among middle-aged Japanese, we showed that long hours of family caregiving increased the risk of incident CHD, especially among women. This increased risk existed after adjusting for lifestyle-related

diseases, health behavior, depressive states and socioeconomic factors. The need for public policies to relieve the caregiving burden for long-hours caregivers considering the sex-related difference is suggested.

Acknowledgements

This study was funded by the Japanese Ministry of Health, Labor and Welfare (H27-seisaku-senryaku-012). The Japanese Ministry of Health, Labor and Welfare approved the secondary use of the data for this study (approval no. 1218-1). This work was carried out as part of the project Health Service Research to Realize Community Care System, undertaken at Tsukuba University, 2015–2016. The authors alone are responsible for the interpretation of the data.

Disclosure statement

The authors declare no conflict of interest.

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BMJ Open

Factors related to prolonged on-scene time during ambulance transportation for critical emergency patients in a big city in Japan: a population-based observational study

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To cite: Nagata I, Abe T, Nakata Y, *et al*. Factors related to prolonged on-scene time during ambulance transportation for critical emergency patients in a big city in Japan: a population-based observational study. *BMJ Open* 2016;**6**:e009599. doi:10.1136/bmjopen-2015-009599

▸ Prepublication history for this paper is available online. To view these files please visit the journal online (http://dx.doi.org/10.1136/bmjopen-2015-009599).

Received 5 August 2015
Revised 21 November 2015
Accepted 24 November 2015

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ABSTRACT

Objectives: We aimed to investigate the factors related to prolonged on-scene times, which were defined as being over 30 min, during ambulance transportation for critical emergency patients in the context of a large Japanese city.

Design: A population-based observational study.

Setting: Kawasaki City, Japan's eighth largest city.

Participants: The participants in this study were all critical patients (age ≥15 years) who were transported by ambulance between April 2010 and March 2013 (N=11 585).

Outcome measures: On-scene time during ambulance transportation for critical emergency patients.

Results: The median on-scene time for all patients was 17 min (IQR 13–23). There was a strong correlation between on-scene time and the number of phone calls to hospitals from emergency medical service (EMS) personnel (p<0.001). In multivariable logistic regression, the number of phone calls to hospitals from EMS personnel, intoxication, minor disease and geographical area were associated with on-scene times over 30 min. Age, gender, day of the week and time of the day were not associated with on-scene times over 30 min.

Conclusions: To make on-scene time shorter, it is vital to redesign our emergency system and important to develop a system that accommodates critical patients with intoxication and minor disease, and furthermore to reduce the number of phone calls to hospitals from EMS personnel.

Strengths and limitations of this study

- Our study population consisted of 11 585 critical patients (age ≥15 years) who were transported by ambulance for 3 years in Japan's eighth largest city.
- This study is the first to focus on factors related to prolonged on-scene time during ambulance transportation for critical emergency patients in a big city.
- Our findings may not be generalisable to rural districts because our study was conducted in a big city.

INTRODUCTION

Total prehospital time consists of response time (the time from ambulance call receipt to arrival of the ambulance at the scene), on-scene time (the time from arrival of the ambulance at the scene to departure), and transport time (the time from departure of the ambulance at the scene to arrival at the hospital). Recently, the Japanese government reported that the average total prehospital time has gradually increased by about 10 min over a decade—from 28.8 min in 2002 up to 38.7 min in 2012.[1]

The prolongation of total prehospital time is a social problem in Japan. It negatively affects the outcomes for critical patients and inhibits the effective utilisation of ambulances.[2–4] Kosaka and Yoshioka[2] reported that hospital mortality for patients with acute cardiac failure was associated with the duration between on-scene time and transport time. Kelly *et al*[3] also showed that patients with ST-elevation myocardial infarction who did not receive thrombolytic therapy within 90 min of calling for medical assistance had an increased risk of death. Therefore, it is very important to reduce the total prehospital time as much as possible. Of the total prehospital time, on-scene time is particularly prolonged because of the expansion of the range of emergency treatments performed by the emergency life-saving technician (ELST) and also by the time taken for hospital selection.[5] Even in big cities where there are a lot of hospitals, the same problems occur.

There have been few studies for prolonged on-scene time during ambulance transportation for critical emergency patients in a big city. Therefore, in this study, we aimed to investigate the factors related specifically to the prolongation of on-scene time during ambulance transportation for critical emergency patients within the context of a large Japanese city.

METHODS

Study design, setting and selection of participants

The study was a population-based observational study conducted in Kawasaki City, the eighth largest city in Japan, with a population of 1.43 million (as of 2013) and a land area of 142.7 km^2.[6] We retrospectively screened every patient who was transported by ambulance in Kawasaki City from 1 April 2010 to 31 March 2013 (N=164 122). Only the patients who the physicians in charge at emergency departments (EDs) classified as critical were included in this study. Critical patients were defined according to the national criteria as those who are expected to be hospitalised for more than 3 weeks or are confirmed dead by the physicians in charge at EDs.[1] We excluded patients who were aged under 15 years and cases of hospital transfer.

The study protocol was reviewed and approved by the Ethics Committee of Teikyo University. The Ethics Committee waived the need for informed consent due to the anonymity of the data collected for routine operations and the retrospective nature of this study.

The Japanese and Kawasaki city's emergency medical service system

The Japanese emergency medical service (EMS) system is operated by a municipality, and its response consists of a single tiered ambulance system that is dispatched for all patients who need ambulance transportation. Each ambulance has at least three EMS personnel, and there is at least one ELST in almost every ambulance. ELSTs are licensed to insert an intravenous line and to place advanced airway management devices for only patients with cardiopulmonary arrest (CPA) under online medical control direction. In addition, specially trained ELSTs are permitted to insert tracheal tubes and to administer intravenous epinephrine for only patients with CPA. Since April 2014, specially trained ELSTs have been permitted to insert an intravenous line and administer intravenous lactated Ringer's solution and to measure the blood glucose and administer intravenous glucose if the patient's blood glucose is low for life-threatening patients. Ambulance service is free of charge.

The Kawasaki Fire Department is responsible for ambulance service in Kawasaki City and had 26 ambulances in 2012. Each ambulance has three EMS personnel, and 99.7% of ambulances had at least one ELST in 2012. Emergency transportations are provided for patients whose symptoms can worsen immediately or who are critically ill, and all patients except those who refuse to travel to hospitals or are already dead are transported to hospitals. Kawasaki city has the checking system for emergency transportation by medical control council. There were three tertiary care emergency centres and 24 acute care hospitals in Kawasaki City in 2012. EMS personnel record initial medical data for all patients whom they transport to hospital on recording papers, and the physicians in charge at EDs check their severities. Finally, the Kawasaki Fire Department keeps them.

Data collection

The data were obtained with the permission of the Kawasaki Fire Department. The data included the following information: age and gender of the patient, the day of the week, the time of the ambulance call, the fire station from which the ambulance was dispatched, the number of phone calls to hospitals from EMS personnel, the disease name as diagnosed at the EDs, response time, on-scene time, and transport time.

Statistical analysis

Prolonged on-scene time was defined as over 30 min because over 30 min is usually used as the prolonged on-scene time in Japanese government reports. To analyse characteristics of patient demographics and backgrounds in relation to on-scene time, normally or near normally distributed continuous variables were presented as means and SD and were compared using the Student t test. Non-normally distributed continuous data were presented as medians and IQRs and were compared using the Wilcoxon rank sum test or Kruskal-Wallis test. Age was divided into three groups: 15–64 years, 65–84 years and over 85 years. Day of the week was divided into 2 groups: weekday and weekend. Time of ambulance call was divided into three groups: night shift (midnight to 08:00), day shift (08:00–16:00), and evening shift (16:00 to midnight). The fire stations from which the ambulances were dispatched were divided into three geographical areas: north, middle and south. The diseases, as diagnosed at the EDs, were divided into 12 groups: CPA, trauma, burn injury, intoxication, other external causes, central neurological diseases, respiratory diseases, cardiovascular diseases, gastrointestinal diseases, renal and urogenital diseases, other internal causes and minor diseases. Other external causes included: heat stroke, hypothermia, hanging, asphyxia, drowning and foreign body. Other internal causes included: disturbance of consciousness and shock of unknown origin, haematological diseases, immunological diseases, endocrine metabolic diseases and neuromuscular diseases. Minor diseases included: eye diseases, skin diseases, nose and throat diseases, obstetrical and gynaecological diseases, psychiatric disorders, breast diseases and orthopaedic diseases except for trauma. Multivariable logistic regression analysis was conducted to investigate the factors related to on-scene time

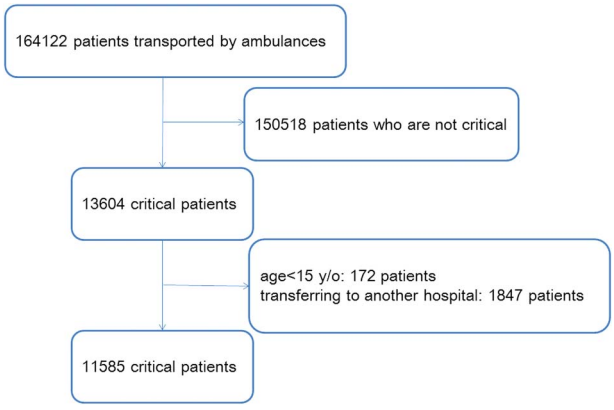

Figure 1 Study profile with selection of participants.

over 30 min. Age, gender and disease as diagnosed at the ED were included in the multivariable logistic regression analysis, and the following variables were applied to multivariable logistic regression analysis using a stepwise selection, if the univariate p value was <0.2: the day of the week, the time of the ambulance call (time of the day), the fire station from which the ambulance was dispatched (geographical area), and the number of phone calls to hospitals from EMS personnel. Data were presented as ORs with 95% CIs. All p-values were two sided, and p<0.05 was considered statistically significant. All analyses were performed using SAS V.9.3 (SAS Institute Inc, North Carolina, USA).

RESULTS

Of 164 122 patients transported by ambulances during the study period, the critical patients numbered 13 604. Among them, 11 585 patients were included in our analysis (figure 1).

Table 1 shows the distribution of response time, on-scene time and transport time. Median on-scene time was 17 min (Q1=25 centile, Q3=75 centile, IQR 13–23).

The demographics and backgrounds of study patients are shown in table 2. On-scene time of age, gender, time of day, geographical area and disease, as diagnosed at the ED, were statistically significant among groups in each category. With regard to the diseases, on-scene times for CPA, trauma, burn injury, intoxication, central neurological diseases, respiratory diseases, cardiovascular diseases, gastrointestinal diseases, other internal causes and minor diseases were statistically significant compared with the other diseases. On-scene times for CPA and cardiovascular diseases were relatively shorter than for the other diseases. On-scene times for trauma, burn injury, intoxication, central neurological diseases, respiratory diseases, gastrointestinal diseases, other internal causes and minor diseases were relatively longer than for the other diseases. Day of the week was not statistically significantly different in each category.

Table 1 The distribution of response time, on-scene time and transport time

	25 centile	Median	75 centile
Response time (min)	6	7	9
On-scene time (min)	13	17	23
Transport time (min)	5	7	11

Figure 2 shows the relationship between on-scene time and the number of phone calls to hospitals from EMS personnel. The more phone calls that were made, the longer was the on-scene time—hence, a strong correlation between the two (Pearson correlation coefficient: 0.57, p<0.001).

The results of the multivariable logistic regression for on-scene time over 30 min are shown in table 3. The number of phone calls to hospitals from EMS personnel, intoxication, minor disease and geographical area were the main factors associated with on-scene times over 30 min. The number of phone calls to hospitals from EMS personnel had a higher OR per phone call (phone calls to hospitals: OR 2.57, p<0.001). Intoxication and minor diseases had higher ORs than the other diseases (intoxication: OR 1.82, p=0.011, minor disease: OR 1.65, p=0.023). As for geographical area, the north and middle areas had higher ORs than the south (the north: OR 3.20, p<0.001, the middle: OR 2.20, p=0.03). Age, gender, day of week, and time of the day had no relationship with on-scene times over 30 min.

DISCUSSION

Key findings

In this study, we found that with regard to ambulance transportation for critical emergency patients in a big city in Japan, the number of phone calls to hospitals from EMS personnel, intoxication, minor disease and geographical area were factors related to prolonged on-scene times over 30 min.

Relationship to previous studies

Our results are in accordance with a number of observational studies in Japan that have reported that on-scene time increased with the number of phone calls to hospitals from EMS personnel regardless of the severity of illness.[7–9] Kitamura *et al*[9] reported that the more phone calls to hospitals from EMS personnel that were made, the longer was the on-scene time for patients with acute myocardial infraction. One prospective population-based cohort study reported that, in Japan, on-scene time is particularly prolonged for suspected drug overdose patients because of the time to obtain acceptance from hospitals to care for them.[10] A population-based observational study, again from Japan, showed that on-scene time of psychiatric emergency services was statistically longer than that of other emergency services.[11] In our study, intoxication was related to prolonged on-scene time over 30 min, and three quarters of those intoxicated patients were suffering from drug overdose and

Table 2 Patient's demographics and backgrounds

	Number	On-scene time (min) Median (IQR)	p Value
Total	11 585	17 (13–23)	
Age (years)			
15–65	3446	17 (13–24)	<0.001
65–85	5261	17 (13–23)	
85+	2878	17 (13–24)	
Gender			
Male	6627	17 (13–23)	<0.001
Female	4958	18 (13–24)	
Day of week			
Weekday	8249	17 (13–23)	0.86
Weekend	3336	17 (13–23)	
Time of the day			
Night shift	2676	18 (13–24)	<0.001
Day shift	4792	17 (13–22)	
Evening shift	4117	17 (13–23)	
Geographical area			
North	2293	19 (15–27)	<0.001
Middle	5035	18 (13–24)	
South	4257	15 (12–20)	
Disease name as diagnosed at emergency departments			
Cardiopulmonary arrest	3678	15 (12–19)	<0.001
External cause			
Trauma	1164	22 (16–31)	<0.001
Burn injury	43	23 (18–30)	<0.001
Intoxication	160	23 (18–30)	<0.001
Other external cause*	163	18 (14–24)	0.26
Internal cause			
Central neurological disease	1536	18 (14–23)	<0.001
Respiratory disease	1436	18 (14–25)	<0.001
Cardiovascular disease	1431	16 (12–22)	<0.001
Gastrointestinal disease	756	18 (14–25)	<0.001
Renal and urogenital disease	85	17 (13–20)	0.88
Other internal disease†	1142	19 (15–26)	<0.001
Minor disease‡	172	20 (14–29)	<0.001

*Other external causes include heat stroke, hypothermia, hanging, asphyxia, drowning and foreign body in an airway.
†Other internal causes included disturbance of consciousness and shock of unknown origin, haematological disease, immunological disease, endocrine metabolic disease and neuromuscular disease.
‡Minor diseases included eye disease, skin disease, nose and throat disease, obstetrical and gynaecological disease, psychiatric disorders, breast disease and orthopaedic disease (except trauma).

likely to have psychiatric disorders. Furthermore, psychiatric disorders were included in our minor disease category, and this category was also related to prolonged on-scene times over 30 min. These findings suggest that on-scene times for drug overdose patients and those with psychiatric disorders were longer even in critical cases.

However, a few studies appear to contradict our results regarding geographical area, patient age and gender, and time of the day.[11–14] Although our results showed that geographical area was associated with prolonged on-scene time over 30 min, a population-based observational study in Canada showed that there was no relation between on-scene time and the area of the city where the study took place. They reported that significant predictors of prolonged on-scene time for patients with chest pain were age, gender and the presence of an advanced life support (ALS) crew.[12] In Japan, to the best of our knowledge, no study has shown the relationship between the geographical area of a city and on-scene time. One reason for the discrepancy between our finding and the Canadian study could well be the fundamental differences of the EMS systems in North America and Japan. In North America, all emergency patients are transferred to EDs in hospitals that provide emergency medicine, where emergency physicians see the emergency patients regardless of their symptoms or severity of their illnesses. On the other hand, in Japan, emergency patients are transferred to hospitals which the EMS personnel select on the basis of the severity of illnesses of patients, which requires the EMS personnel to call ahead to appropriate hospitals to ask if they can

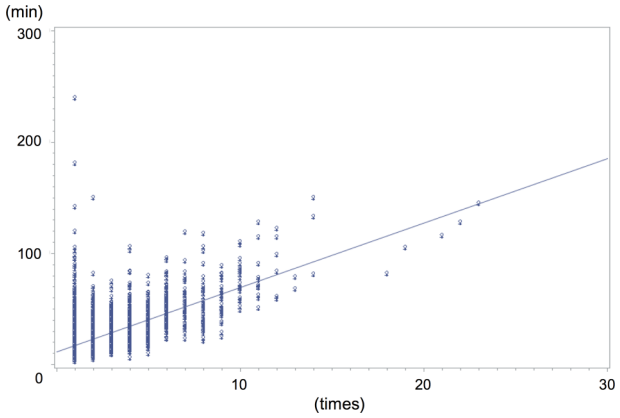

Figure 2 The relationship between on-scene time and number of phone calls to hospitals from emergency medical service personnel.

accommodate the patient. Another reason for the discrepancy between our result and those of the other study could well be due to the differences in the emergency medical systems of hospitals in Japan. For example, at some hospitals, the emergency physicians get a call directly from the EMS personnel, and at other hospitals, information clerks or nurses receive the call first and then ask each medical specialist if he/she can see and treat the emergency patient. Therefore, the talk time between the EMS personnel and the hospital in this latter case is likely to be longer than in the former case. Furthermore, in Japan, there are regional differences in the EMS and treatment offered at different hospitals. Several studies, for example, have reported differences in on-scene time between metropolitan cities and rural areas, and the survival outcomes of out-of-hospital cardiac arrest among seven different geographic regions of the country.[14–16] Similar to Kawasaki city, it is possible that the differences in the emergency medical systems of tertiary care emergency centres and acute care hospitals in Kawasaki city affect on-scene time of geographical area.

Table 3 Multivariable logistic regression analysis for on-scene time over 30 min

	OR (95% CI)	p Value
Age (years)	1.00 (0.99 to 1.01)	0.32
Gender		
Male	0.92 (0.80 to 1.05)	0.22
Disease name as diagnosed at emergency departments		
Cardiopulmonary arrest	0.30 (0.24 to 0.38)	<0.001
Trauma	1.19 (0.94 to 1.51)	0.15
Intoxication	1.82 (1.15 to 2.87)	0.011
Other external cause	0.58 (0.33 to 1.02)	0.058
Central neurological disease	0.48 (0.37 to 0.61)	<0.001
Respiratory disease	0.63 (0.49 to 0.80)	<0.001
Cardiovascular disease	0.37 (0.28 to 0.48)	<0.001
Gastrointestinal disease	0.68 (0.51 to 0.91)	0.010
Minor disease	1.65 (1.06 to 2.57)	0.023
Time of the day		
Night shift	1.15 (0.96 to 1.36)	0.068
Evening shift	0.98 (0.84 to 1.15)	0.24
Day shift	1.00	
Phone calls to hospitals	2.57 (2.43 to 2.72)	<0.001
Geographical area		
North	3.20 (2.65 to 3.87)	<0.001
Middle	2.20 (1.85 to 2.61)	0.003
South	1.00	

In our study, using multivariable logistic regression, we found that age, gender and time of the day were not related to on-scene times over 30 min. However some previous studies have shown that age (per decade), gender (female) and time of the day (night shift) were related to prolonged on-scene time.[11–14] These differences might be caused by differences in study population, outcome variables, statistical analysis and covariates. Our study included only critical patients, defined the outcome variable as on-scene time over 30 min, and conducted multivariable statistical analysis for the outcome variable. The influence of age, gender and time of the day on on-scene time may decrease in more specific cases as in our study.

Significance and implications

A survey made by the Japanese Fire and Disaster Management Agency reports that the number of patients transported by ambulances has increased year by year. The number of patients transported by ambulances in 2012 was 5.25 million people, the highest number ever, and an increase of 67 thousand people from 2011.[1] A possible cause for this increase could be a rise in the number of mild and moderately ill patients who were transported by ambulances.[1] However, in Japan, there is a concurrent annual decrease in the number of emergency medical facilities which will accept such patients.[17] Therefore, mild and moderately ill patients may be transported to tertiary care hospitals, which may affect on-scene time for EMSs to transport critical patients due to overcrowding.

Strengths and limitations

To the best of our knowledge, this study is the first to focus on prolonged on-scene time of ambulance transportation for critical emergency patients in a big city. The results of our study showed that in a big city the difference in geographical area affected on-scene time over 30 min for critical patients. It also showed that intoxication and the number of phone calls to hospitals from EMS personnel were related to prolonged on-scene time, even for critical patients.

Our study has a number of limitations. First, our results are considered to be useful with regard to big cities in Japan, as a few studies conducted in other big cities have reported similar results.[7–10] However, our results may not adapt to rural districts and other countries. This study would be useful for big cities in other

countries because they might enhance the welfare as universal coverage and free service for ambulance like Japan in future. Second, this study's participants were critical patients who had various diseases because illness-specific, injury mechanism-specific and on-scene specific aspects could affect on-scene time. Third, it is possible that our study population might include patients who were not critical, due to the fact that the definition of a critical patient used in this study (those who are expected to be hospitalised for more than 3 weeks or are confirmed dead by a doctor), in accordance with the national criteria, is somewhat vague. Fourth, the severity of a patient's condition might not reflect the severity at that time when the ambulance was called, because the assessment of the severity of the patient's condition was conducted after arrival at the hospital. Some patients might deteriorate during transportation and be assessed as critically ill at the hospitals. Therefore, it is possible that some patients in our study were misclassified, and further study is perhaps needed with a more defined selection of symptom severity.

CONCLUSIONS

Our study, based in a big city in Japan, has shown that for ambulance transport for critical emergency patients the number of phone calls to hospitals from EMS personnel, intoxication, minor diseases and geographical area were factors related to prolonged on-scene times of over 30 min. To reduce on-scene time, it is vital to redesign our emergency system and important to develop a system that accommodates critical patients with intoxication and minor diseases and furthermore to reduce the number of phone calls to hospitals from EMS personnel.

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Acknowledgements The authors would like to acknowledge the Kawasaki Fire Department, and Thomas D Mayers for his English language manuscript revision.

Contributors IN collected the data, conceived the study, participated in its design and performed the statistical analysis, and also wrote the manuscript. TA contributed to the design of the study and drafted the manuscript. YN and NT contributed to the design of the study and critically revised the manuscript. All the authors read and approved the final manuscript.

Funding This study was supported by the Ministry of Health, Labour and Welfare (H27-seisaku-senryaku-012).

Competing interests None declared.

Ethics approval The Ethics Committee of Teikyo University.

Provenance and peer review Not commissioned; externally peer reviewed.

Data sharing statement No additional data are available.

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Factors related to prolonged on-scene time during ambulance transportation for critical emergency patients in a big city in Japan: a population-based observational study

Isao Nagata, Toshikazu Abe, Yoshinori Nakata and Nanako Tamiya

BMJ Open 2016 6:
doi: 10.1136/bmjopen-2015-009599

PLOS | ONE

RESEARCH ARTICLE

The Impact of Leisure and Social Activities on Activities of Daily Living of Middle-Aged Adults: Evidence from a National Longitudinal Survey in Japan

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OPEN ACCESS

Citation: Monma T, Takeda F, Noguchi H, Takahashi H, Tamiya N (2016) The Impact of Leisure and Social Activities on Activities of Daily Living of Middle-Aged Adults: Evidence from a National Longitudinal Survey in Japan. PLoS ONE 11(10): e0165106. doi:10.1371/journal.pone.0165106

Editor: Jong-Ling Fuh, Taipei Veterans General Hospital, TAIWAN

Received: March 13, 2016

Accepted: October 6, 2016

Published: October 27, 2016

Data Availability Statement: The data used in this study are collected by the Ministry of Health, Labour and Welfare (MHLW) in Japan and therefore, users of these data are strictly limited to those who obtain official permission from the Minister of Health, Labour and Welfare, in accordance with Japanese Article 33 (Provision of Questionnaire Information) of the Statistics Act, by the Statistic Bureau, Ministry of Internal Affairs and Communications. Qualified researchers who would like to request access to the data should contact

Abstract

This study investigated the effects of leisure and social activities on the ability of middle-aged adults to maintain activities of daily living (ADL), and whether performing these activities alone or with others contributed to the ability to perform ADL. The study used nationally representative longitudinal data of 22,770 adults in Japan, aged 50–59 years, who did not have limitations in performing ADL at the beginning of the 5-year survey period. The study considered six activity categories: two leisure activities ("hobbies or cultural activities" and "exercise or sports") and four social activities ("community events," "support for children," "support for elderly individuals," and "other social activities"). Multiple logistic regression analysis was used to examine the relation between participation in these categories at baseline and difficulties in ADL at the 5-year follow-up. The association between the extent of social interaction during these activities ("by oneself," "with others," or "both") and difficulties in ADL was also investigated. The analysis yielded significant negative correlations between "exercise or sports" and difficulties in ADL for both men and women, and between "hobbies or cultural activities" and difficulties in ADL for women. However, these significant relationships occurred only when activities were conducted "with others." The present findings might help prevent deterioration in middle-aged adults' performance of ADL in Japan.

Introduction

Although the Japanese have a relatively long lifespan, the gap between mean life expectancy and healthy life expectancy (i.e. the number of years that a person can expect to live in full

the Statistics and Information Department of the MHLW. Please refer to the following URL: http://www.mhlw.go.jp/toukei/sonota/chousahyo.html.

Funding: This study was supported by the Ministry of Health, Labour and Welfare (H27-seisaku-senryaku-012).

Competing Interests: The authors have declared that no competing interests exist.

health) is still 9.13 years for men and 12.68 years for women [1]. This gap refers to the period of experiencing limitations in daily activities and leads to individuals with a decreased quality of life who may become a burden to the national social security system. Therefore, extending healthy life expectancy and reducing the gap between mean life expectancy and healthy life expectancy is important for both public health and financial sustainability [1]. Maintaining health and avoiding unhealthy behaviors in midlife would reduce the risk of disabilities later in life [2]. Thus approaches that focus on healthy practices of middle-aged adults are necessary to extend healthy life expectancy.

Healthy life expectancy of Japanese individuals is calculated based on activity limitations in the Comprehensive Survey of Living Conditions (CSLC) [3], a nationally representative survey conducted by the Ministry of Health, Labour and Welfare (MHLW) [4]. Specific types of activity limitations were described including "activities of daily living (ADL)," "going out," "work, household, and studies," and "exercise" [3]. Among these, the ability to perform ADL is fundamental to maintaining an active daily life [5], which suggests that effective approaches to maintaining ADL should be widely encouraged.

A number of studies found that leisure activities (e.g. hobbies, cultural activities, exercise, and sports) and social activities (e.g. volunteering and community activities) help maintain ADL in older adults. For example, a 4-year longitudinal study in Japan reported that participation in hobby activities decreased the risk of functional disability among older adults [6]. Another Japanese study using 3-year longitudinal data reported that participation in hobby groups could effectively maintain older adults' effectance, which represents higher-level functional capacity [7]. Furthermore, some meta-analyses have indicated that interventions involving exercise or sports can effectively maintain ADL in older adults [8, 9]. A longitudinal study targeting middle-aged adults also indicated a positive effect of exercise/sports on maintaining ADL [10]. Regarding social activities, longitudinal studies of older adults found that engaging in volunteer work was associated with decreased functional dependency [11, 12].

In addition, the presence of others participation in these activities may contribute to preventing deterioration in ADL performance (ADL deterioration). A study of older adults in Japan found that even when exercise was performed no more than once a week, the incidence of functional disabilities among those participating with others was lower than among those who exercised alone [13]. This finding suggests that social relationships may be a key factor in the prevention of functional disabilities. A systematic review reported that poor social relationships contributed to declines in functional status [14]. Thus, in addition to the positive effects of leisure and social activities themselves, social relationships developed through these activities are likely to promote maintenance of ADL.

However, no research has simultaneously examined the effects of middle-aged adults' leisure and social activities on the maintenance of ADL; nor have studies investigated whether the effects of these activities are affected by the presence of other persons.

Our previous study investigated the effect of leisure and social activities on middle-aged adults' mental health status, and considered the impact of the presence of other persons participating in the activity as an additional variable, using nationally representative longitudinal data from the Longitudinal Survey of Middle-aged and Elderly Persons (LSMEP) [15] conducted in Japan by the MHLW. It reported that leisure activities were related to mental health status at the 5-year follow-up, and that participation in leisure activities was strongly related to the presence of others [16]. While the previous study focused on the effect of leisure and social activities on mental health, this study examines the effect of these activities on ADL among middle-aged adults in Japan, using the LSMEP data.

Methods

Study population and procedure

This study used data extracted from the LSMEP, a nationwide, population-based survey, conducted in Japan by the MHLW each year since 2005. Respondents to the survey were extracted randomly through stratified two-stage sampling. First, 2,515 districts were selected at random from the complete set of 5,280 districts surveyed in the CSLC, conducted in 2004 by the MHLW. Subsequently, 40,877 residents of each selected district were randomly chosen from individuals aged 50–59 years, in proportion to the district's total population.

In 2005, the first year of the survey, questionnaires were dropped off at the respondents' homes by enumerators who returned to collect the self-reported surveys several days later. From the second year of the survey, the delivery method of the questionnaire changed from a "drop-off" to mail, and respondents returned the questionnaire by mail; the questionnaire was sent only to those who answered the questionnaire either last year, the year before, or both. The LSMEP did not recruit any new respondents since the survey's first year.

We used data from the first and sixth surveys, in 2005 and 2010. Of the 40,877 people who received the original questionnaire, 34,240 responded to the survey in 2005 (response rate: 83.8%). Of these, we excluded 2,322 respondents with missing values regarding difficulties in ADL in 2005 and 2,737 respondents who had difficulties in ADL as of 2005 that could have prevented them from engaging in leisure and social activities, such as exercise or sports, leaving 29,181 eligible baseline respondents. Then, these respondents were contacted each year, provided they continued to complete the survey. As a result, the study sample comprised 22,770 respondents who completed the survey in 2010 (follow-up rate: 78.0%).

We obtained official permission to use the LSMEP from the MHLW based on Article 33 of the Statistics Act. We obtained the data in a fully anonymized and de-identified form. An ethical review was not required, based on the Japanese government's Ethical Guidelines for Epidemiological Research [17].

Measurements

Difficulties in ADL. Subjects' difficulties in ADL were evaluated by responses to the question: "Do you have any difficulties in activities of daily living as follows: walking, getting up from a bed or a floor, sitting down and standing up from a chair, dressing, washing one's hands or face, eating, toilet use, bathing, going up and down stairs, and carrying shopping bags?" Dichotomized responses (yes/no) were recorded.

Leisure and social activities. As with our previous study [16], two types of leisure activities were assessed: "hobbies or cultural activities (e.g. playing the Japanese game *go*, working with potted plants, traveling)" and "exercise or sports (e.g. walking, playing in a ball game)," and four types of social activities were assessed: "community events (e.g. neighborhood associations functions)," "support for children (e.g. assistance for children's clubs)," "support for elderly individuals (e.g. support of housekeeping, transportation)," and "other social activities." Respondents were asked whether they had participated in each activity during the year prior to the survey. For each question, those answering "yes" and "no" were categorized as active and inactive, respectively. Active respondents were asked to indicate the way in which they primarily participated in each activity: "by oneself," "with families or friends," "with co-workers (including former co-workers)," "in a neighborhood community association," or "in a non-profit organization or public-interest corporation." Respondents were permitted to select more than one response option. For the present study, respondents were categorized into three groups for each activity: "by oneself," "with others" or "both" (i.e. doing the activity both "alone" and "with others").

Demographic and socioeconomic status. Demographic and socioeconomic status included age (calculated from the month and year of birth), gender, living arrangement (i.e. living with a spouse, child(ren), father, mother, father-in-law, and mother-in-law, respectively), job status (employed or unemployed), personal income, and family care provision, which was evaluated by the question: "do you provide care for your family?" with dichotomized responses (yes/no).

Health status. Respondents' answers regarding the presence of chronic diseases (diabetes, heart diseases, cerebral stroke, high blood pressure, hyperlipidemia, and cancer) were rated on a dichotomized scale (yes or no).

Mental health status was assessed using the Japanese version of the K6 scale [18], a screening tool for disorders involving psychological distress according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) [19]. Respondents answered six K6 items on a 5-point Likert scale, and responses for each item were transformed into scores ranging from 0–4 points. The total score ranged from 0 to 24. A higher total score corresponds to poorer mental health status. The respondents were divided into two groups, "good mental health status" (score below 5 points) or "poor mental health status" (5 points or above) according to the 5-point optimal cutoff for screening mood and anxiety disorders in Japan (with 100% sensitivity and 68.7% specificity) that has been used in previous Japanese studies [20, 21]. The Japanese version of the K6 has been validated [18], and the internal consistency reliability (Cronbach's alpha) of the scale in this study was 0.87.

Health behaviors

Health behaviors included smoking status ("smoker" or "non-smoker") and alcohol drinking status ("drinker" or "nondrinker").

Statistical analysis

We used multiple imputation by chained equations to handle missing data in this study. Analysis of imputed datasets reduces the effects of potential biases introduced by missing data [22]. This method assumes that data are missing at random, and that any systematic differences between missing and observed values can be explained by differences in observed data [23]. Missing values were imputed according to a model comprising all other variables, and multiple imputation was used to create and analyze 10 multiple imputed datasets.

To investigate the relationship between the six types of leisure and social activities in the baseline survey and difficulties in ADL in the follow-up survey, two kinds of multiple logistic regression models were applied. Model 1 included the six types of activities ("hobbies or cultural activities," "exercise or sports," "community events," "support for children," "support for elderly individuals," and "other social activities") separately, as independent variables. Because the proportion of people who engaged in "support for children," "support for elderly individuals," and "other social activities" was low, the statistical power of these items was likely to be low. Therefore, the independent factors in Model 2 were two types of leisure activities ("hobbies or cultural activities" and "exercise or sports") and a summarized index referred to as "social activities" indicated involvement in at least one of the four social activities. Furthermore, we conducted chi-square analyses and individual t-tests to compare the characteristics of active and inactive respondents with regard to leisure activities (participating in at least one of "hobbies or cultural activities" and "exercise or sports").

Multiple logistic regression analyses were also performed to examine the impact of the sociality of activities (by oneself, with others, both ways, or not at all) on reducing difficulties in ADL. We used leisure and social activities that had positive effects in reducing difficulties in

ADL in the prior logistic regression analyses as independent variables. Demographic and socioeconomic status (age, living arrangement, job status, personal income, and family care provision), health status (presence of chronic diseases and mental health status), and health behaviors (smoking status and alcohol drinking status) at baseline were controlled in the multiple logistic regression analyses. Logistic regression analyses, chi-square analyses, and individual t-tests were performed by gender because the proportion of respondents reporting participation in leisure and social activities in the baseline survey and limitations in ADL in the follow-up survey differed according to gender.

The level of significance for all analyses was set at $p < 0.05$. All statistical analyses were performed using IBM SPSS version 23.0.

Results

A total of 17,856 respondents answered questions to all variables used in this study (78.4% of respondents in this study). The number of missing cases of each variable before multiple imputation by gender and by age (50–54 years old or 55–59 years old in the baseline survey) is shown in S1 and S2 Tables, respectively.

Descriptive statistics of the sample's characteristics after multiple imputation are shown in Table 1. A larger proportion of women reported limitations in ADL in the follow-up survey compared to men. In addition, a larger proportion of women participated in "hobbies or cultural activities," "support for children," "support for elderly individuals," and "other social activities" than did men; on the other hand, a greater percentage of men reported participation in "exercise or sports" and "community events" than did women.

Table 2 presents the results of the multiple logistic regression analyses investigating the relationship between the six types of leisure and social activities at baseline and difficulties in ADL at follow-up. For men, "exercise or sports" decreased the risk of ADL difficulties at the 5-year follow-up (odds ratio [OR]: 0.70, 95% confidence interval [CI]: 0.58–0.84, $p < 0.001$) in Model 1. Model 2 also found a significant relationship between "exercise or sports" and fewer difficulties in men's ADL (OR: 0.75, 95% CI: 0.62–0.89, $p < 0.01$).

With regard to women, "hobbies or cultural activities" (OR: 0.80, 95% CI: 0.69–0.94, $p < 0.01$) and "exercise or sports" (OR: 0.79, 95% CI: 0.68–0.92, $p < 0.01$) decreased the risk of difficulties in ADL at follow-up in Model 1. In contrast, "support for children" (OR: 1.61, 95% CI: 1.21–2.13, $p < 0.001$) and "support for elderly individuals" (OR: 1.32, 95% CI: 1.01–1.74, $p < 0.05$) increased this risk. Similarly, Model 2 showed that "hobbies or cultural activities" (OR: 0.84, 95% CI: 0.72–0.98, $p < 0.05$) and "exercise or sports" (OR: 0.86, 95% CI: 0.75–1.00, $p < 0.05$) decreased the risk of difficulties in ADL, whereas social activities (OR: 1.17, 95% CI: 1.02–1.35, $p < 0.05$) were associated with increased risk.

Subsequently, respondent characteristics were examined according to whether they engaged in leisure activities (Table 3). Significant differences in several variables were observed between active and inactive respondents with regard to leisure activities, because of the large sample size. In particular, the proportion of active respondents with poor mental health and smoking behavior was less than that of inactive respondents. Further, the average personal income of active men was much higher than that of inactive men. A smaller proportion of active women lived with their mother-in-law compared to inactive women.

Then, associations between social aspects of respondents' engagement in "hobbies or cultural activities" or "exercise or sports" and difficulties in ADL were examined (Table 4). The "inactive" category was used as the reference. For men, "exercise or sports" was significantly related to reduced difficulty with ADL only when it was performed with others (OR: 0.68, 95% CI: 0.53–0.86, $p < 0.01$). Similarly, among women, both "hobbies or cultural activities" and

Table 1. Characteristics of respondents after multiple imputation of missing values.

	Men (n = 11,029)				Women (n = 11,741)				P-value
	Mean (SE)		n (%)		Mean (SE)		n (%)		
Demographic and socioeconomic status									
Age	54.71	(0.03)			54.67	(0.03)			0.281[b]
Living arrangement:									
Spouse present			9619	(87.2)			9903	(84.3)	<0.001[c]
Child(ren) present			6970	(63.2)			7217	(61.5)	0.007[c]
Father present			1224	(11.1)			386	(3.3)	<0.001[c]
Mother present			2686	(24.4)			968	(8.2)	<0.001[c]
Father-in-law present			268	(2.4)			763	(6.5)	<0.001[c]
Mother-in-law present			615	(5.6)			1914	(16.3)	<0.001[c]
Employed			10510	(95.3)			8337	(71.0)	<0.001[c]
Personal income[a]	48.35	(0.65)			16.58	(0.32)			<0.001[b]
Family care provider			662	(6.0)			1204	(10.3)	<0.001[c]
Health status									
Diabetes			927	(8.4)			475	(4.0)	<0.001[c]
Heart diseases			342	(3.1)			163	(1.4)	<0.001[c]
Cerebral stroke			118	(1.1)			71	(0.6)	<0.001[c]
High blood pressure			2070	(18.8)			1764	(15.0)	<0.001[c]
Hyperlipidemia			1017	(9.2)			1018	(8.7)	0.145[c]
Cancer			119	(1.1)			199	(1.7)	<0.001[c]
Poor mental health			2529	(22.9)			2940	(25.0)	<0.001[c]
Health behaviors									
Smoker			5156	(46.7)			1301	(11.8)	<0.001[c]
Drinker			8241	(74.7)			3605	(32.7)	<0.001[c]
Leisure and social activities									
Hobbies or cultural activities			6593	(59.8)			7830	(66.7)	<0.001[c]
Exercise or sports			5460	(49.5)			5482	(46.7)	<0.001[c]
Community events			3655	(33.1)			3730	(31.8)	0.027[c]
Support for children			990	(9.0)			1218	(10.4)	<0.001[c]
Support for elderly individuals			921	(8.4)			1344	(11.4)	<0.001[c]
Other social activities			1448	(13.1)			1688	(14.4)	0.006[c]
Difficulties in ADL at follow-up			652	(5.9)			984	(8.4)	<0.001[c]

[a] Ten thousand yen.

[b] Independent t-test.

[c] Chi-square test.

doi:10.1371/journal.pone.0165106.t001

"exercise or sports" were significantly and negatively correlated with difficulties in ADL only when it was performed with others (hobbies or cultural activities: OR: 0.80, 95% CI: 0.66–0.97, $p < 0.05$; exercise or sports: OR: 0.74, 95% CI: 0.57–0.95, $p < 0.05$).

Discussion

In the previous Japanese study using LSMEP data, we showed that middle-aged women's and men's participation in leisure activities such as "hobbies or cultural activities" and "exercise or sports" with others was related to mental health status at the 5-year follow-up [16]. In this study, multiple logistic regression analyses of the selected LSMEP data revealed that "exercise or sports" for both genders and "hobbies or cultural activities" for women were related to ADL

Table 2. Results of multiple logistic regression analyses for the relationships between leisure and social activities and ADL.

		Model 1[a]			Model 2[a]		
		OR	95% CI	P-value	OR	95% CI	P-value
Men							
Hobbies or cultural activities	Active (ref. Inactive)	0.91	0.76–1.09	0.315	0.95	0.80–1.13	0.561
Exercise or sports	Active (ref. Inactive)	0.70	0.58–0.84	<0.001	0.75	0.62–0.89	0.001
Community events	Active (ref. Inactive)	1.02	0.83–1.24	0.875			
Support for children	Active (ref. Inactive)	1.33	0.88–2.01	0.172			
Support for elderly individuals	Active (ref. Inactive)	1.13	0.74–1.72	0.566			
Other social activities	Active (ref. Inactive)	1.19	0.84–1.69	0.315			
Social activities	Active (ref. Inactive)				1.11	0.93–1.33	0.246
Women							
Hobbies or cultural activities	Active (ref. Inactive)	0.80	0.69–0.94	0.005	0.84	0.72–0.98	0.023
Exercise or sports	Active (ref. Inactive)	0.79	0.68–0.92	0.002	0.86	0.75–1.00	0.050
Community events	Active (ref. Inactive)	0.98	0.82–1.16	0.807			
Support for children	Active (ref. Inactive)	1.61	1.21–2.13	<0.001			
Support for elderly individuals	Active (ref. Inactive)	1.32	1.01–1.74	0.045			
Other social activities	Active (ref. Inactive)	0.99	0.67–1.46	0.967			
Social activities	Active (ref. Inactive)				1.17	1.02–1.35	0.029

[a] Adjusted for demographic and socioeconomic status (age, living arrangement, job status, personal income, and family care provision), health status (the presence of chronic diseases and mental health status), and health behaviors (smoking status and alcohol drinking status) at baseline.
Ref: reference; OR: Odds ratio; CI: Confidence interval.

doi:10.1371/journal.pone.0165106.t002

status at the 5-year follow-up only when these activities were conducted with others. This finding suggests that among leisure and social activities, participation in exercise or sports with others may effectively promote or maintain ADL and mental health in middle-aged men and women.

Our findings are consistent with several longitudinal studies that have reported that exercise or sports prevent ADL deterioration among older adults [24–26] and middle-aged adults [10]. On the other hand, some previous studies have suggested that hobbies or cultural activities decreased the risk of functional disabilities among older adults [6, 7]. The present study found significant longitudinal relationships between hobbies or cultural activities and reduced difficulties in ADL only among middle-aged women. This finding is of particular significance when designing intervention strategies for middle-aged women whose physical capacities do not permit them to engage in exercise or sports.

Furthermore, comparisons of active and inactive respondents, determined by whether they participated in leisure activities, yielded significant results. Active individuals were less likely to smoke and more likely to be in good mental health. In fact, poor mental health [27] and smoking [10] were considered to increase the risk of difficulties in ADL. Moreover, active men had significantly higher average personal incomes compared to inactive men. This is consistent with other studies that found a longitudinal impact of economic factors on ADL [28], with a greater effect on men's health than on women's health [29, 30]. Further, a significantly smaller proportion of active women—compared to inactive women—lived with their mother-in-law. Living with one's mother-in-law may limit women's available leisure time. These factors may contribute to preventing ADL difficulties by promoting participation in leisure activities.

Importantly, the present study indicated that participating in leisure activities with others might help maintain ADL. The findings suggest that only two baseline factors, participating in hobbies or cultural activities (among women) and exercise or sports (for both genders) with

Table 3. Characteristics of active and inactive respondents with regard to leisure activities.

	Men (*n* = 11029)						Women (*n* = 11741)					
	Leisure activities				χ^2 or t	P-value	Leisure activities				χ^2 or t	P-value
	Inactive		Active[a]				Inactive		Active[a]			
	n (%) or Mean (SE)		n (%) or Mean (SE)				n (%) or Mean (SE)		n (%) or Mean (SE)			
Demographic and socioeconomic status												
Age	54.64	(0.05)	54.76	(0.03)	1.583[c]	0.114	54.49	(0.05)	54.74	(0.03)	4.184[c]	<0.001
Living arrangement:												
Spouse present	2644	(85.4)	6975	(87.9)	12.717[d]	<0.001	2498	(83.6)	7405	(84.6)	1.557[d]	0.212
Child(ren) present	1974	(63.8)	4996	(63.0)	0.586[d]	0.444	1938	(64.9)	5279	(60.3)	19.460[d]	<0.001
Father present	343	(11.1)	880	(11.1)	0.000[d]	0.983	95	(3.2)	291	(3.3)	0.148[d]	0.701
Mother present	793	(25.6)	1893	(23.9)	3.755[d]	0.053	252	(8.4)	716	(8.2)	0.190[d]	0.663
Father-in-law present	89	(2.9)	179	(2.3)	3.604[d]	0.058	218	(7.3)	545	(6.2)	4.216[d]	0.040
Mother-in-law present	191	(6.2)	424	(5.3)	2.875[d]	0.090	575	(19.3)	1339	(15.3)	25.521[d]	<0.001
Employed	2930	(94.6)	7580	(95.6)	4.130[d]	0.042	2258	(75.6)	6079	(69.4)	40.507[d]	<0.001
Personal income[b]	41.55	(1.08)	51.00	(0.79)	6.594[c]	<0.001	15.70	(0.53)	16.87	(0.39)	1.613[c]	0.107
Family care provider	178	(5.8)	484	(6.1)	0.481[d]	0.488	276	(9.2)	928	(10.6)	4.511[d]	0.034
Health status												
Diabetes	239	(7.7)	688	(8.7)	2.627[d]	0.105	117	(3.9)	358	(4.1)	0.171[d]	0.679
Heart diseases	111	(3.6)	231	(2.9)	3.375[d]	0.066	45	(1.5)	118	(1.3)	0.409[d]	0.522
Cerebral stroke	39	(1.3)	79	(1.0)	1.465[d]	0.226	24	(0.8)	47	(0.5)	2.633[d]	0.105
High blood pressure	557	(18.0)	1513	(19.1)	1.682[d]	0.195	465	(15.6)	1299	(14.8)	0.926[d]	0.336
Hyperlipidemia	248	(8.0)	769	(9.7)	7.538[d]	0.006	205	(6.9)	813	(9.3)	16.527[d]	<0.001
Cancer	31	(1.0)	88	(1.1)	0.243[d]	0.622	50	(1.7)	149	(1.7)	0.011[d]	0.918
Poor mental health	819	(26.5)	1710	(21.6)	30.230[d]	<0.001	849	(28.4)	2091	(23.9)	24.296[d]	<0.001
Health behaviors												
Smoker	1692	(54.7)	3464	(43.7)	108.388[d]	<0.001	468	(15.7)	833	(9.5)	85.553[d]	<0.001
Drinker	2234	(72.2)	6007	(75.7)	14.698[d]	<0.001	775	(26.0)	2830	(32.3)	42.637[d]	<0.001

[a] Respondents who participated at least one of "hobbies or cultural activities" and "exercise or sports."

[b] Ten thousand yen.

[c] Individual *t*-test.

[d] Chi-square test.

doi:10.1371/journal.pone.0165106.t003

others were associated with reduced deterioration in ADL at follow-up. One possible explanation is that social relationships may enhance the benefit gained from these activities. One study showed that middle-aged individuals with consistently high levels of social relationships over a 34-year period leading up to old age had a lower risk of disability in their later years compared to those whose social relationships that decreased with time or remained at constant low to medium levels [31]. Another study on older adults in Japan showed that functional disability could be prevented more effectively when people were engaged in sports or exercise with others in organizations rather by exercising alone [13]. Our results suggest that social relationships provided by leisure activities, and not necessarily the activities themselves, might be key to maintaining ADL.

Nonetheless, these results may be influenced by differences in the sample size. The number of respondents participating in leisure activities with others was much larger than any other group. Although there were no significant relationships between engaging in leisure activities

Table 4. Multiple logistic regression analyses investigating the relationships between social aspects of activities and difficulties in ADL.

	Men				Women			
	n	OR[a]	95% CI	P-value	n	OR[a]	95% CI	P-value
Hobbies or cultural activities (ref: Inactive)								
By oneself					1560	0.78	0.60–1.02	0.069
With others					5884	0.80	0.66–0.97	0.022
Both					386	1.17	0.69–1.99	0.554
Exercise or sports (ref: Inactive)								
By oneself	1725	0.81	0.63–1.03	0.086	1788	0.90	0.73–1.09	0.281
With others	3387	0.68	0.53–0.86	0.002	3316	0.74	0.57–0.95	0.022
Both	348	0.79	0.23–2.74	0.705	377	1.15	0.48–2.74	0.752

[a] Adjusted for demographic and socioeconomic status (age, living arrangement, job status, personal income, and family care provision), health status (the presence of chronic diseases and mental health status), and health behaviors (smoking status and alcohol drinking status) at baseline.
Ref: reference; OR: Odds ratio; CI: confidence interval.

doi:10.1371/journal.pone.0165106.t004

both "alone" and "with others" and difficulties in ADL, the sample size of this group was particularly small, implying that these results need to be considered carefully.

On the other hand, men's and women's participation in any of the four categories of social activities at baseline was not associated with limitations in ADL at follow-up. However, some studies targeting older adults have found such a relationship; for example, two longitudinal studies indicated that volunteering was associated with decreased functional dependency [11, 12]. This difference between results may be attributable to the considerably older sample in these studies. Older adults lose their social roles and their feelings regarding life being worth living with age [32, 33], and these in turn affect ADL [34] and other health outcomes [35]. Thus, engaging in social activities may provide opportunities to maintain social roles and one's feeling that life is worth living, which may be especially important for ADL maintenance among older adults. However, in our study on middle-aged adults (50–59 years), 95.3% of men and 71.0% of women were employed at baseline. In other words, almost all respondents had other forms of regular social involvement. Therefore, it is understandable that participating in specific social activities does not contribute to preventing ADL deterioration in middle-aged adults.

Furthermore, women who engaged in social activities, especially those who support children and elderly individuals, may be more likely to have difficulties in ADL than those who did not engage in these activities. Previous studies have demonstrated a high prevalence of musculoskeletal pain—especially lower-back pain—in women with family-caregiving [36] or childcare [37, 38] responsibilities, and that this pain lead to difficulties in ADL [39]. In particular, women's bone mass [40] and muscle mass [40] decreases rapidly with decreased estrogen levels post-menopause; further, postmenopausal women are at risk of osteoporosis and sarcopenia [41]. Thus, social activities may be risk factors for ADL deterioration via negative effects of musculoskeletal problems in middle-aged women.

The present study has several limitations related to the research process and sample. First, the most important limitation of this study is that it cannot claim a causal relationship between participation in leisure and social activities and maintenance of ADL. It is possible that causal relationships between these factors are the inverse of our hypothesis. Therefore, it is thus plausible that those who were more proficient in ADL at baseline were more likely to engage in various activities. Thus, directionality should be analyzed in future studies. Second, despite using multiple imputation to avoid the impact of missing variables, selection bias may exist. About

6,000 people did not respond to the baseline questionnaire, and about 6,000 respondents had dropped out at the end of 5 years. This limitation should be considered when generalizing the findings. Third, although we used multiple imputation methods to reduce the effect caused by attrition bias [42], it is impossible to prove that data are missing at random, rather than missing not at random. The examination of similarities of missing proportions between exposures and outcomes showed varied results. For example, in men, the missing proportion of exposures was 0–10.7% and that of outcomes was 3.1%; in women, this missing proportion of exposures was 0–7.9% and that of outcomes was 4.1%. Similarly, in respondents aged 50–54 in the baseline survey, the missing proportion of exposures was 0–9.3% and that of outcomes was 2.9%; in respondents aged 55–59 in the baseline survey, the missing proportion of exposures was 0–9.2% and that of outcomes was 4.2%. Because we did not have a complete set of the data, the influence of missing patterns on the results could not be determined. However, there is a possibility that missing values of some variables were not missing at random, and that the differences in missing patterns influenced the relationships between leisure and social activities and difficulties in ADL. Fourth, because participation in leisure and social activities was assessed using a dichotomized scale, the frequency or variety of each individual's participation is unknown. Fifth, this study depended largely on respondents' self-reported and retrospective answers regarding leisure and social activities, which may lead to less accurate results. Sixth, the LSMEP excluded hospitalized patients and residents of nursing homes who may have extraordinarily complex difficulties in performing ADL and do not to engage in leisure and social activities. The positive results in this study may therefore be underestimated. Finally, other confounders that are related to ADL, such as obesity or body mass index, [43] were not taken into account in this study.

Despite the above-mentioned limitations, the present study has several strengths. It used a large sample size and nationally representative data, and therefore reduced the effect caused by selection bias. Further, our study examined a wide range of leisure and social activities; it is more comprehensive than previous studies on middle-aged adults in Japan. Finally, in addition to our previous study, which recommends effective ways of promoting mental health, the present findings suggest that it is more effective for middle-aged adults to engage in leisure activities with others.

In conclusion, the present study found that exercise or sports for both genders and hobbies or cultural activities for women may have positive effects on ADL maintenance among middle-aged adults in Japan when these activities are performed with others. These findings might be useful when designing and developing strategies to encourage maintenance of ADL among middle-aged adults in Japan.

Supporting Information

S1 Table. The number of missing cases of each variable by gender.
(DOCX)

S2 Table. The number of missing cases of each variable by age.
(DOCX)

Acknowledgments

This study was supported by the Ministry of Health, Labour and Welfare (H27-seisaku-senryaku-012).

Author Contributions

Conceptualization: FT.

Data curation: TM HN.

Formal analysis: TM FT HN HT.

Funding acquisition: NT.

Methodology: TM FT HT.

Project administration: FT NT.

Writing – original draft: TM.

Writing – review & editing: FT HN HT NT.

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