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Social networks and mortality based on the Komo-Ise cohort study in Japan

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Background No prospective studies have examined the association between social networks and all-cause and cause-specific mortality among middle-aged Japanese. The study of varied populations may contribute to clarifying the robustness of the observed effects of social networks and extend their generalizability.

Methods To clarify the association between social networks and mortality among middle-aged and elderly Japanese, a community-based prospective study, the Komo-Ise Study, was conducted in two areas of Gunma Prefecture, Japan. A total of 11 565 subjects aged 40–69 years at baseline in 1993 completed a self-administered questionnaire. During the 7-year follow-up period, 335 men and 155 women died and the relative risk (RR) of each social network item was estimated by the Cox proportional hazard model.

Results Single women had significantly increased risks of all-cause (multivariate RR = 2.2), and all circulatory system disease (age-area adjusted RR = 2.6) mortality. Men who did not participate in hobbies, club activities, or community groups had significantly higher multivariate RR for all-cause (RR = 1.5), all circulatory system disease (RR = 1.6) and non-cancer and non-circulatory system disease (RR = 2.3) mortality. Urban women who rarely or never met close relatives had significantly elevated risks of all-cause (RR = 2.4), all cancer (RR = 2.6), and non-cancer and non-circulatory system disease (RR = 2.7) mortality after adjustment for established risk factors.

Conclusions This study provides evidence that social networks are an important predictor of mortality risk for middle-aged and elderly Japanese men and women. Lack of participation, for men, and being single and lack of meeting close relatives, for women, were independent risk factors for mortality.

Keywords Social networks, social support, mortality, middle-age, elderly, prospective study, Japan

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Over the last 20 years a vast literature has been accumulated that links social networks or social support with physical and mental health. Social networks represent the web of social relationships that we each maintain, including both intimate relationships with family and close friends and more formal relationships with other individuals and groups.[1] Large prospective cohort studies have been conducted and have shown that people who are isolated or disconnected from others are at increased risk of dying prematurely.[2–7] One of the earlier cohort studies was the Alameda County Study. Berkman *et al.*[2] examined four social network sources: (1) marriage; (2) contact with close friends and relatives; (3) church membership; and (4) informal and formal group associations, and found that each of these four social network sources predicted all-cause mortality independently of the other three. Reynolds *et al.*[3] reported that socially isolated women were at a significantly elevated risk of cancer mortality. Another study, the Tecumseh Community Health Study,[4] replicated and extended Berkman's work in the Alameda County Study. House *et al.*[4] reported that only men with higher levels of social relationships and activities were significantly less likely to die during the follow-up period. The Evans County Cardiovascular Epidemiologic Study[5] also replicated Berkman's study of social networks and mortality in

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Alameda County, but Schoenbach *et al.*[5] found evidence of a relationship between social networks and mortality only among white men, with the social network effects among white women and black men and women being weaker and clearly non-significant. Outside the US, studies in Finland and Sweden[6,7] have described results similar to those of the Tecumseh Community Health Study and the Evans County Cardiovascular Epidemiologic Study and they showed an increased risk of cardiovascular diseases mortality.

Although we have accumulated a great deal of knowledge on the association between social networks and mortality,[1,8] the findings have been inconsistent and some important issues remain unanswered. First, the vast majority of the studies on social networks and health have been conducted in Western developed countries, and hence are constrained to within the Western sociocultural context. To our knowledge, no prospective studies have ever investigated the association between social networks and all-cause and cause-specific mortality among middle-aged Japanese men and women.[9,10] The study of diverse populations may contribute to clarifying the robustness of the observed effects of social networks and extend the generalizability of particular observations or theories. Second, most of the studies have focussed on the associations between social networks and all-cause mortality, although some studies provided evidence that social isolation is associated with an increased risk of cardiovascular diseases mortality and all cancer mortality.[3,6] As the mortality profile in Japan differs from those in Western countries, findings from assessing the relationship between social networks and cause-specific mortality may allow interpretation of potential mechanisms. The purpose of this study is to clarify the association between social networks and all-cause and cause-specific mortality among middle-aged and elderly Japanese.

Materials and Methods

Study population

The Komo-Ise Study, for which some notable results have already been reported elsewhere,[11–13] covered two research areas of Gunma Prefecture, Japan: Komochi Village and Isesaki City. The subjects were all male and female residents aged 40–69 years, 4875 in Komochi Village and 7755 in a downtown district of Isesaki City, identified in the municipal resident registration file, *Jumin Kihon Daicho,* that covers almost every resident of Komochi Village as of September 1992 and of Isesaki City as of August 1993.

Self-administered questionnaires were distributed through the respective municipal government offices to all subjects of Komochi Village in January 1993 and to those of the downtown district of Isesaki City in October 1993, and the completed questionnaires were collected in sealed envelopes. A combined total of 11 565 subjects from both areas responded to the questionnaire (response rate: total 91.6%, rural area 92.3%, urban area 91.1%) in the baseline survey. Ohta *et al.*[12] have already reported that the non-response bias and selection bias were negligible in this baseline study.

Study variables

The questionnaire consisted of items on social network, socio-demographic characteristics, lifestyle, health status, and a symptom checklist, the Todai Health Index (THI).[14,15]

Social network items

Social network items in the present study comprised seven factors: (1) marital status (Marriage); (2) household size (Household); (3) number of meeting close relatives (Relatives); (4) having reliable friends (Friends); (5) participation in activities (Participation); (6) going to any religious services (Religion); and (7) enjoying good fellowship with neighbours (Neighbourhood). Respondents were asked the following questions in regard to each item: (1) What is your current marital status: married, single, divorced, or widowed?; (2) How many people do you live with?; (3) How often do you meet close relatives not living with you: almost daily, >10 times a month, 5–9 times a month, 1–4 times a month, a few times a year, or rarely or never?; (4) When you are in need, do you have close friends you can turn to: yes or no?; (5) How often do you take part in hobbies, club activities, or community groups: very often, often, sometimes, or never?; (6) Do you go to any religious services: yes or no?; (7) Do you enjoy good fellowship with your neighbours: yes or no? The responses to all seven items except for Marriage and Household were coded into dichotomous categories. Marriage was coded into four categories: married; single; divorced; and widowed. The responses to the Relatives item, almost daily, >10 times a month, 5–9 times a month, and 1–4 times a month were combined into one category. The responses to the Participation item, very often, often, and sometimes were combined into one category.

Other items

Respondents were asked about their longest-held occupation, not about their current employment status. In the present study, they were grouped into dichotomous categories: any kind of occupation and no occupation. Educational background was coded into dichotomous categories: compulsory education, high school, vocational school or special school, versus junior college and college or higher. Smoking habit was coded as never smoked, former smokers, and current smokers. Alcohol consumption was assessed by asking: Do you drink a lot of alcoholic beverages: yes, drink a little, or never? Responses were coded into dichotomous categories: yes versus drink a little and never. Body mass index (BMI), calculated from self-reported data, was coded into three categories: <18.5, $18.5–<25.0$, and $\geqslant 25.0$. Respondents were also asked whether they had any chronic diseases.

Follow-up procedures

We followed a total of 11 565 subjects from 1993 to 2000. Information on deaths and migrations was obtained from the municipal resident registration file, *Jumin Kihon Daicho*, in each area. During the follow-up period, 490 deaths (335 among men, 155 among women) were observed. There were 145 (2.6%) and 126 (2.1%) censored cases among the men and women, respectively. These small numbers were considered to have negligible effects on the results of this study.[12] Cause of death was determined from death certificates, *Shibo-Kohyo*, in the local public health centre, with the permission of the Management and Co-ordination Agency, the Government of Japan. According to the *International Classification of Diseases 10th Revision* (ICD-10), causes of death were coded as follows; deaths from all cancers (ICD-10: C00–C97), all circulatory system diseases (ICD-10: I00–I99), ischaemic heart diseases (ICD-10: I20–I25), and cerebrovascular diseases (ICD-10: I60–I69). We added a mail inquiry to reach subjects who had migrated out of the study area. Subjects who did not respond to the mail inquiry or who had not been reached were regarded as censored cases.[12] The observation period for five men and women was not confirmed in spite of a careful follow-up survey (n = 5628, men; n = 5932, women).

Statistical methods

All analyses were performed independently for men and women. The Cox proportional hazards model was used to estimate age-area adjusted and multivariate relative risks (RR) with 95% Confidence Intervals (CI) of all-cause and cause-specific mortality by each social network item at baseline using SPSS version 10.0J for Windows. The proportional hazard assumptions were confirmed by log of the negative log plots of survivor function. Multivariate RR were adjusted for age (10-year age categories), area (rural, urban), occupation (any kind of occupation, no occupation), educational background (junior college and college or higher, lower than high school), smoking habit (never, past, current), alcohol consumption (never and light, heavy), body mass index (BMI) (<18.5, $18.5 \leqslant \text{BMI} < 25$, $\geqslant 25$), and chronic disease (any, no) for men and these variables except for alcohol consumption for women. With respect to marriage, height (quintile) was added to age-area and multivariate adjustments in order to assess the effect for selection factor.[16,17] In order to examine whether the association between each social network item and mortality was modified by area (rural or urban), a product term with each social network item and area was included in a model adjusting age. As interactions were observed in neighbourhood for men and relatives for women, relative risks were calculated by area.

Results

Table 1 shows the baseline characteristics according to social network items among men and women. In general, married men and women were associated with a favourable profile of socioeconomic and lifestyle factors. Divorced men and women showed larger proportions of those living in the urban area, highly educated, current smokers and heavy drinkers than the other three groups. Widowed men and women were older, of lower mean height, and more likely to have chronic diseases than the other three groups. Men and women living alone were more likely to live in the urban area and to smoke than people living with more than two others. The profile about relatives was nearly identical. Men and women who had reliable friends were younger, more educated, and less likely to have chronic diseases than those who did not have reliable friends, although they were associated with an unfavourable lifestyle profile. Participation in activities was associated with high education and less with having chronic diseases for either sex. Women who participated in activities were less likely to smoke and drink heavily than those who did not participate in activities, although for men they were nearly identical. The larger proportions of subjects who went to religious services lived in the urban area and had chronic diseases. Men who went to religious services were less heavy drinkers than those who did not go to religious services but women in this category smoked more and drank heavily. To enjoy good fellowship with neighbours was associated with being old, living in the rural area, and a smaller proportion of highly educated subjects. Men who enjoyed good fellowship with neighbours had an unfavourable lifestyle profile.

Table 2 shows the number of deaths, person-years, and RR according to social network items for all-cause and cause-specific mortality among men. Single or divorced men had significantly increased risks of all-cause (RR = 1.8 and 2.3) and non-cancer and non-circulatory system disease mortality (RR = 3.3 and 7.2) compared to married men after adjusting for age and area. Relative risks for all circulatory system disease, ischaemic heart disease, and cerebrovascular disease mortality were relatively high among single, divorced, and widowed men. As the number of deaths was too few to estimate RR related to cause-specific mortality, multivariate RR were calculated for only all-cause mortality. The multivariate RR for single or divorced men were still high (RR = 1.5 and 1.6) but neither of them reached the 0.05 level of significance. Men with a larger household size had a significantly lower age-area adjusted and multivariate RR for all-cause mortality (RR = 0.92 and 0.91) than those with a smaller household size. However, statistically significant lower RR were not seen for any cause-specific mortalities. Men who did not participate in activities had significantly higher age-area adjusted and multivariate RR for all-cause (RR = 1.7 and 1.5), all circulatory system disease (RR = 1.9 and 1.6), and non-cancer and non-circulatory system disease (RR = 2.7 and 2.3) mortality, though not all cancer mortality. Lack of participation in activities was associated with cerebrovascular disease rather than ischaemic heart disease mortality risk. Relatives, friends, religion, and neighbourhood were not significantly associated with all-cause and any cause-specific mortality risks.

Results for the number of deaths, person-years, and RR according to social network items for all-cause and cause-specific mortality among women are shown in Table 3. Single women had a significantly higher age-area adjusted and multivariate RR for all-cause mortality (RR = 1.9 and 2.2) than married women. Higher age-area adjusted RR were observed for any cause-specific mortality except for all cancer but only the RR for all circulatory system disease mortality showed significant elevation. No significant association was found between divorced and widowed women and all-cause and any specific cause mortality. Although women who rarely or never met close relatives demonstrated elevated age-area adjusted and multivariate RR for all-cause and any cause-specific mortality except for ischaemic heart disease mortality, only age-area adjusted and multivariate RR for all-cause showed significant elevations (RR = 1.7 and 1.8). Women who did not participate in activities were at a significantly increased age-area adjusted risk for all-cause (RR = 1.5) and non-cancer and non-circulatory system disease (RR = 3.2) mortality. Although multivariate RR for all circulatory system disease mortality was high, statistical significance was seen only for non-cancer and non-circulatory system disease mortality (RR = 2.6). Household, friends, religion, and neighbourhood were not significantly associated with all-cause and any cause-specific mortality risk.

Table 4 shows the age-area adjusted and multivariate RR for all-cause mortality further adjusted by adding height. Compared to findings in Table 2 and 3, RR for all-cause mortality were unchanged even after adjusting for height.

Table 5 shows findings assessed by area with respect to neighbourhood for men and relatives for women. Rural men who

Table 1 Baseline characteristics according to social network items among men and women

Variable	Marriage				Household		Relatives		Friends		Participation		Religion		Neighbourhood	
	Married	Single	Divorced	Widowed	Living alone	More than 2	Often, sometimes	A few, never	Yes	No	Yes	No	Yes	No	Yes	No
Men																
Age (mean, [SD])	54.3 (8.4)	46.9 (5.8)	51.6 (8.0)	59.0 (7.7)	52.9 (8.7)	54.0 (8.5)	55.7 (8.4)	53.9 (8.2)	53.5 (8.6)	54.4 (8.3)	54.0 (8.5)	53.6 (8.4)	55.2 (8.2)	53.8 (8.5)	55.7 (8.3)	52.9 (8.4)
Area, urban (%)	60	66	73	54	77	59	62	59	56	64	60	59	71	59	55	62
Occupation, no occupation (%)	3	6	6	10	9	3	4	4	3	5	3	5	4	4	4	4
Education, junior college and college or higher (%)	21	16	22	12	16	20	18	23	21	18	21	17	21	20	14	23
Smoking habit, current smoker (%)	55	62	70	69	69	57	58	55	59	56	57	58	56	58	60	56
Alcohol consumption, heavy (%)	27	20	31	28	27	27	27	28	28	25	27	25	20	27	29	26
Body mass index, (mean, [SD])	23.1 (2.7)	22.8 (3.0)	22.8 (3.2)	22.8 (3.0)	22.7 (2.9)	23.1 (2.8)	23.0 (2.8)	23.0 (2.7)	23.2 (2.7)	22.9 (2.9)	23.1 (2.7)	22.8 (2.9)	22.9 (2.8)	23.0 (2.8)	23.0 (2.8)	23.1 (2.8)
Chronic diseases (%)	35	32	39	40	38	35	37	36	32	39	33	39	40	35	35	35
Height (cm), (mean, [SD])	164.8 (6.2)	164.6 (6.9)	164.3 (5.7)	162.5 (7.1)												
Women																
Age (mean, [SD])	53.7 (8.3)	54.1 (9.1)	52.7 (8.5)	60.8 (6.4)	59.9 (7.8)	54.1 (8.3)	54.9 (8.3)	54.4 (8.6)	54.1 (8.4)	55.2 (8.4)	54.9 (8.3)	53.4 (8.5)	55.1 (8.7)	54.4 (8.4)	55.9 (8.1)	53.1 (8.4)
Area, urban (%)	63	81	82	63	84	61	64	61	62	66	64	61	80	62	62	64
Occupation, no occupation (%)	30	19	12	25	23	28	28	29	26	31	28	28	28	28	29	27
Education, junior college and college or higher (%)	17	17	19	11	14	16	15	17	17	13	17	14	19	16	13	18
Smoking habit, current smoker (%)	10	19	32	13	20	12	12	12	13	12	11	16	18	12	12	13
Alcohol consumption, heavy (%)	2	3	9	3	5	2	2	3	3	2	2	3	4	2	2	3
Body mass index. (mean, [SD])	23.1 (3.0)	21.9 (3.4)	22.4 (3.1)	23.2 (3.4)	22.1 (3.4)	23.1 (3.1)	23.2 (3.0)	22.8 (3.0)	23.0 (3.0)	23.0 (3.2)	23.0 (3.0)	23.0 (3.2)	23.3 (3.4)	23.0 (3.0)	23.3 (3.1)	22.7 (3.0)
Chronic diseases (%)	35	43	34	43	44	35	36	37	34	39	35	37	41	35	37	34
Height (cm), (mean, [SD])	152.8 (5.3)	153.0 (5.9)	153.0 (5.7)	150.8 (5.5)												

Table 2 Number of deaths, person-years, and relative risks (RR) according to social network items for all-cause and cause-specific mortality among men

Type of mortality		All-causes	All cancer	All circulatory system disease	Ischaemic heart disease	Cerebro-vascular disease	Non-cancer and non-circulatory system disease
Marriage							
Married	31 950.18 person-years						
No. of deaths		263	127	75	21	26	61
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
Single	2369.30 person-years						
No. of deaths		15	2	6	2	2	7
Age-area adjusted RR[a]		1.75	0.53	2.27	3.02	1.94	3.33
(95% CI)		(1.02–3.01)	(0.13–2.20)	(0.94–5.47)	(0.64–14.15)	(0.43–8.81)	(1.45–7.62)
Multivariate adjusted RR[b]		1.52					
(95% CI)		(0.81–2.85)					
Divorced	897.76 person-years						
No. of deaths		13	1	2	1	1	10
Age-area adjusted RR[a]		2.27	0.37	1.24	2.21	1.72	7.21
(95% CI)		(1.30–3.97)	(0.05–2.63)	(0.30–5.07)	(0.29–16.55)	(0.23–12.80)	(3.66–14.19)
Multivariate adjusted RR[b]		1.61					
(95% CI)		(0.79–3.29)					
Widowed	1158.15 person-years						
No. of deaths		13	5	6	3	3	2
Age-area adjusted RR[a]		0.99	0.78	1.57	2.75	2.36	0.68
(95% CI)		(0.57–1.73)	(0.32–1.92)	(0.68–3.62)	(0.81–9.31)	(0.71–7.87)	(0.17–2.77)
Multivariate adjusted RR[b]		1.11					
(95% CI)		(0.62–2.00)					
Household	37 954.98 person-years						
Per each additional person							
No. of deaths		327	146	94	28	34	87
Age-area adjusted RR[a]		0.92	0.91	0.97	1.00	0.88	0.88
(95% CI)		(0.86–0.99)	(0.82–1.01)	(0.85–1.10)	(0.79–1.26)	(0.70–1.11)	(0.76–1.01)
Multivariate adjusted RR[b]		0.91	0.90	0.94	0.81	0.88	0.90
(95% CI)		(0.84–0.99)	(0.80–1.02)	(0.81–1.09)	(0.60–1.10)	(0.69–1.13)	(0.76–1.06)
Relatives							
Often, sometimes	19 889.56 person-years						
No. of deaths		201	101	53	16	22	47
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
A few, never	8328.10 person-years						
No. of deaths		71	25	23	6	7	23
Age-area adjusted RR[a]		0.97	0.69	1.20	1.04	0.89	1.32
(95% CI)		(0.74–1.27)	(0.44–1.06)	(0.73–1.96)	(0.41–2.68)	(0.38–2.10)	(0.80–2.18)
Multivariate adjusted RR[b]		0.89	0.65	1.07	0.86	0.68	1.21
(95% CI)		(0.65–1.21)	(0.40–1.06)	(0.61–1.87)	(0.28–2.63)	(0.25–1.84)	(0.67–2.19)
Friends							
Yes	22 327.03 person-years						
No. of deaths		185	83	55	16	19	47
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
No	15 275.96 person-years						
No. of deaths		128	58	34	11	15	36
Age-area adjusted RR[a]		0.94	0.94	0.87	0.95	1.09	1.04
(95% CI)		(0.75–1.18)	(0.67–1.31)	(0.57–1.33)	(0.44–2.05)	(0.55–2.16)	(0.67–1.61)
Multivariate adjusted RR[b]		0.82	0.80	0.92	0.96	1.16	0.74
(95% CI)		(0.64–1.06)	(0.55–1.16)	(0.57–1.47)	(0.41–2.27)	(0.55–2.42)	(0.45–1.24)

Continued

Table 2 Continued

Type of mortality	All-causes	All cancer	All circulatory system disease	Ischaemic heart disease	Cerebro-vascular disease	Non-cancer and non-circulatory system disease
Participation						
Yes 27 487.55 person-years						
No. of deaths	196	100	54	22	19	42
(Ref.)	1.00	1.00	1.00	1.00	1.00	1.00
No 10 226.66 person-years						
No. of deaths	118	40	37	5	13	41
Age-area adjusted RR[a]	1.68	1.12	1.87	0.62	1.89	2.71
(95% CI)	(1.33–2.11)	(0.78–1.62)	(1.23–2.85)	(0.24–1.65)	(0.93–3.83)	(1.76–4.17)
Multivariate adjusted RR[b]	1.50	1.08	1.63	0.44	1.79	2.26
(95% CI)	(1.16–1.93)	(0.72–1.61)	(1.02–2.61)	(0.13–1.49)	(0.83–3.85)	(1.38–3.69)
Religion						
Yes 1931.77 person-years						
No. of deaths	20	10	8	1	4	2
(Ref.)	1.00	1.00	1.00	1.00	1.00	1.00
No 36 102.38 person-years						
No. of deaths	304	137	81	26	29	86
Age-area adjusted RR[a]	0.92	0.83	0.60	1.60	0.43	2.61
(95% CI)	(0.58–1.44)	(0.44–1.58)	(0.29–1.25)	(0.22–11.77)	(0.15–1.23)	(0.64–10.61)
Multivariate adjusted RR[b]	0.90	0.73	0.79	NA[c]	0.48	1.85
(95% CI)	(0.54–1.49)	(0.37–1.44)	(0.32–1.95)		(0.14–1.60)	(0.45–7.57)
Neighbourhood						
Yes 13 515.01 person-years						
No. of deaths	140	64	40	11	13	36
(Ref.)	1.00	1.00	1.00	1.00	1.00	1.00
No 24 338.69 person-years						
No. of deaths	178	81	48	15	19	49
Age-area adjusted RR[a]	0.87	0.90	0.82	0.93	1.00	0.87
(95% CI)	(0.69–1.09)	(0.64–1.25)	(0.54–1.26)	(0.42–2.04)	(0.49–2.05)	(0.56–1.35)
Multivariate adjusted RR[b]	0.81	0.87	0.85	0.86	1.08	0.69
(95% CI)	(0.64–1.04)	(0.60–1.24)	(0.53–1.35)	(0.37–2.02)	(0.50–2.34)	(0.42–1.13)

[a] Adjusted for age (10-year age categories) and area (rural, urban).

[b] Adjusted for age (10-year age categories), area (rural, urban), occupation (any kind of occupation, no occupation), educational background (junior college and college or higher, lower than high school) smoking habit (never, past, current) alcohol consumption (never and light, heavy), body mass index (<18.5, 18.5≤BMI<25, 25≥BMI), and chronic disease (any, no).

c Not available.

did not enjoy good fellowship with their neighbours had a significantly decreased risk of all-cause (RR = 0.64 for multivariate) and non-cancer and non-circulatory system disease (RR = 0.31 for multivariate) mortality, although this was not the case for urban men for all-cause and any cause-specific mortality risks. Only for urban women, lack of meeting close relatives was significantly associated with increasing risks for all-cause (RR = 2.4 for multivariate), all cancer (RR = 2.6 for multivariate) and non-cancer and non-circulatory system disease (RR = 2.7 for multivariate) mortality.

Discussion

This study provides evidence that social network items are an important predictor of mortality risk for middle-aged and elderly Japanese men and women, although the results for some of the seven social network items showed gender or area differences. Lack of participation in activities, for men, and being single, for women, and lack of meeting close relatives, for urban women, were independent risk factors for mortality.

Marriage

Because it is one of the most basic and intimate bonds between people, Marriage is the single social tie that has been most examined for links with mortality.[16–18] Our findings showed that only single women had significantly increased mortality risk after adjustment for potential confounding factors, while single and divorced men had increased mortality risk. This association with all-cause mortality persisted after exclusion of subjects in the first 4 years of the 7-year follow-up period (RR = 2.5, 95% CI: 1.0–6.0) or those who had any chronic diseases (RR = 2.1, 95% CI: 0.9–4.7) (data not shown). The increased risks of death for single men and women were mainly attributable to all-circulatory system disease and non-cancer and non-circulatory system disease. Similar results were obtained from the British Regional Heart Study in England.[18] However,

Table 3 Number of deaths, person-years and relative risks (RR) according to social network items for all-cause and cause-specific mortality among women

Type of mortality		All-causes	All cancer	All circulatory system disease	Ischaemic heart disease	Cerebro-vascular disease	Non-cancer and Non-circulatory system disease
Marriage							
Married		31 621.65 person-years					
No. of deaths		101	42	32	6	16	27
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
Single		1869.74 person-years					
No. of deaths		12	3	5	1	2	4
Age-area adjusted RR[a]		1.91	1.10	2.61	3.29	1.91	2.43
(95% CI)		(1.05–3.49)	(0.34–3.57)	(1.01–6.73)	(0.38–28.11)	(0.44–8.35)	(0.84–7.00)
Multivariate adjusted RR[b]		2.19					
(95% CI)		(1.17–4.09)					
Divorced		1636.53 person-years					
No. of deaths		6	3	2	0	1	1
Age-area adjusted RR[a]		1.20	1.35	1.34	NA[c]	1.23	0.76
(95% CI)		(0.52–2.74)	(0.42–4.38)	(0.32–5.61)		(0.16–9.31)	(0.10–5.65)
Multivariate adjusted RR[b]		0.95					
(95% CI)		(0.34–2.63)					
Widowed		3682.31 person-years					
No. of deaths		21	8	8	0	5	5
Age-area adjusted RR[a]		1.19	1.11	1.50	NA[c]	1.86	0.98
(95% CI)		(0.74–1.92)	(0.51–2.40)	(0.68–3.31)		(0.67–5.18)	(0.37–2.58)
Multivariate adjusted RR[b]		1.30					
(95% CI)		(0.77–2.21)					
Household							
Per each additional person		40 731.19 person-years					
No. of deaths		149	58	47	8	24	44
Age-area adjusted RR[a]		0.95	1.01	0.90	0.91	0.99	0.92
(95% CI)		(0.86–1.05)	(0.86–1.18)	(0.74–1.09)	(0.60–1.40)	(0.77–1.28)	(0.77–1.11)
Multivariate adjusted RR[b]		0.91	0.95	0.87	0.83	0.94	0.89
(95% CI)		(0.81–1.03)	(0.79–1.15)	(0.69–1.09)	(0.48–1.44)	(0.67–1.32)	(0.72–1.10)
Relatives							
Often, sometimes		25 565.85 person-years					
No. of deaths		79	33	26	4	14	20
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
A few, never		8147.57 person-years					
No. of deaths		41	16	13	1	8	12
Age-area adjusted RR[a]		1.73	1.61	1.69	0.76	1.98	1.96
(95% CI)		(1.18–2.52)	(0.89–2.93)	(0.87–3.30)	(0.09–6.85)	(0.83–4.72)	(0.96–4.01)
Multivariate adjusted RR[b]		1.78	1.79	1.72	0.86	2.50	1.84
(95% CI)		(1.17–2.71)	(0.95–3.38)	(0.80–3.72)	(0.09–8.55)	(0.86–7.26)	(0.82–4.15)
Friends							
Yes		28 030.04 person-years					
No. of deaths		99	44	31	5	17	24
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
No		12 230.16 person-years					
No. of deaths		46	13	16	3	8	17
Age-area adjusted RR[a]		0.99	0.63	1.09	1.38	0.96	1.55
(95% CI)		(0.70–1.41)	(0.34–1.16)	(0.60–2.00)	(0.33–5.80)	(0.41–2.23)	(0.83–2.88)
Multivariate adjusted RR[b]		0.86	0.50	0.86	1.16	0.90	1.57
(95% CI)		(0.58–1.29)	(0.24–1.03)	(0.41–1.80)	(0.21–6.49)	(0.31–2.61)	(0.80–3.07)

Continued

Table 3 Continued

Type of mortality		All-causes	All cancer	All circulatory system disease	Ischaemic heart disease	Cerebro-vascular disease	Non-cancer and Non-circulatory system disease
Participation							
Yes	28 999.18 person-years						
No. of deaths		93	46	28	6	16	19
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
No	11 474.87 person-years						
No. of deaths		49	10	17	2	7	22
Age-area adjusted RR[a]		1.48	0.61	1.72	0.89	1.26	3.23
(95% CI)		(1.05–2.10)	(0.31–1.21)	(0.94–3.16)	(0.18–4.41)	(0.52–3.08)	(1.75–5.98)
Multivariate adjusted RR[b]		1.31	0.53	1.71	0.47	1.58	2.55
(95% CI)		(0.89–1.94)	(0.25–1.15)	(0.86–3.41)	(0.05–4.17)	(0.56–4.44)	(1.30–5.02)
Religion							
Yes	2886.17 person-years						
No. of deaths		14	7	4	0	3	3
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
No	37 852.98 person-years						
No. of deaths		134	51	44	8	22	39
Age-area adjusted RR[a]		0.78	0.61	0.89	NA[c]	0.64	1.01
(95% CI)		(0.45–1.35)	(0.28–1.34)	(0.32–2.50)		(0.19–2.15)	(0.31–3.28)
Multivariate adjusted RR[b]		1.33	0.94	2.85	NA[c]	1.45	1.32
(95% CI)		(0.61–2.86)	(0.33–2.63)	(0.39–20.94)		(0.19–11.18)	(0.31–5.57)
Neighbourhood							
Yes	19 003.86 person-years						
No. of deaths		69	27	24	5	12	18
(Ref.)		1.00	1.00	1.00	1.00	1.00	1.00
No	21 417.64 person-years						
No. of deaths		73	29	20	2	11	24
Age-area adjusted RR[a]		1.12	1.12	0.88	0.41	0.97	1.45
(95% CI)		(0.80–1.56)	(0.66–1.90)	(0.49–1.61)	(0.08–2.16)	(0.42–2.21)	(0.78–2.70)
Multivariate adjusted RR[b]		1.18	1.26	0.89	0.60	0.83	1.37
(95% CI)		(0.81–1.71)	(0.70–2.26)	(0.43–1.82)	(0.09–3.82)	(0.28–2.42)	(0.70–2.70)

[a] Adjusted for age (10-year age categories) and area (rural, urban).

[b] Adjusted for age (10-year age categories) area (rural, urban), occupation (any kind of occupation, no occupation), educational background (junior college and college or higher, lower than high school), smoking habit (never, past, current), body mass index (<18.5, $18.5 \leq \text{BMI} < 25$, ≥ 25), and chronic disease (any, no).

[c] Not available.

in another study of middle-aged British men, Ben-Shlomo *et al.*[16] concluded that single status itself did not increase risk because the RR was attenuated by height as a marital selection factor. In the present study, the same association was not observed for men and women. However for women, Cheung *et al.*[17] reported that only single women showed excess mortality risk even after taking established risk factors, even if height as a selection factor, into account. There are two plausible interpretations of our findings. One is that 'social control' leads to improved health status through better preventive health behaviours and practices, with the ultimate result of reduced mortality risk. Although Umberson[19] reported that marriage might benefit the health of men more than women partly because marriage provides more social control for men, married men and women, even if divorced or widowed, might benefit from social control more than single subjects. The other is that social networks may act as a buffer against stressful life events through social support, resulting in a reduction of the health-damaging effects of these stressors on the individual over time.[20] Married women might have greater advantages through not only emotional support, but also instrumental support, as the income of working women is generally lower than that of men,[21] and it is more difficult for the former to be economically independent. However, we shall not discuss this any further, because stress and the quality or functional aspects of relationships were not evaluated in this study.

Relatives and participation

Our findings revealed lack of participation in activities, for men, and lack of meeting close relatives, for urban women, as independent risk factors for mortality. These associations with all-cause mortality persisted after exclusion of subjects in the first 4 years of the 7-year follow-up period or those who had any chronic diseases (data not shown). With respect to participation

Table 4 Relative risks (RR) for all-cause mortality in relation to marital status further adjusted for height

Marriage		Men	Women
Married	(Ref.)	1.00	1.00
Single	Age-area adjusted RR[a]	1.50	1.99
	(95% CI)	(0.84–2.67)	(1.09–3.64)
	Multivariate adjusted RR[b]	1.49	2.20
	(95% CI)	(0.79–2.80)	(1.18–4.12)
Divorced	Age-area adjusted RR[a]	2.28	1.26
	(95% CI)	(1.30–3.99)	(0.55–2.89)
	Multivariate adjusted RR[b]	1.61	0.98
	(95% CI)	(0.79–3.29)	(0.35–2.70)
Widowed	Age-area adjusted RR[a]	0.99	1.21
	(95% CI)	(0.57–1.73)	(0.75–1.96)
	Multivariate adjusted RR[b]	1.11	1.27
	(95% CI)	(0.61–1.99)	(0.75–2.16)

[a] Adjusted for age (10-year age categories), area (rural, urban) and height (quintile).

[b] Adjusted for age (10-year age categories), area (rural urban), occupation (any kind of occupation, no occupation), educational background (junior college and college or higher, lower than high school), smoking habit (never, past, current), alcohol consumption (never and light, heavy), body mass index (<18.5, 18.5⩽BMI<25, ⩾25), chronic disease (any, no) and height (quintile) for men and these variables except for alcohol consumption for women.

Table 5 Relative risks (RR) for all-cause and cause-specific mortality by area and social network items for Neighbourhood and Relatives

Type of mortality		All-causes	All cancer	All circulatory system disease	Non-cancer and non-circulatory system disease
Neighbourhood for men					
Rural					
Yes	(Ref.)	1.00	1.00	1.00	1.00
No	Age-adjusted RR	0.56	0.65	0.79	0.27
	(95% CI)	(0.39–0.82)	(0.37–1.12)	(0.41–1.51)	(0.11–0.63)
	Multivariate adjusted RR[a]	0.64	0.76	0.86	0.31
	(95% CI)	(0.42–0.97)	(0.41–1.41)	(0.41–1.79)	(0.12–0.80)
Urban					
Yes	(Ref.)	1.00	1.00	1.00	1.00
No	Age-adjusted RR	1.13	1.10	0.85	1.60
	(95% CI)	(0.84–1.52)	(0.71–1.68)	(0.49–1.50)	(0.88–2.89)
	Multivariate adjusted RR[a]	0.93	0.94	0.83	1.06
	(95% CI)	(0.68–1.27)	(0.60–1.47)	(0.46–1.51)	(0.56–2.00)
Relatives for women					
Rural					
Often, sometimes	(Ref.)	1.00	1.00	1.00	1.00
A few, never	Age-adjusted RR	0.90	0.46	1.09	1.37
	(95% CI)	(0.42–1.91)	(0.10–2.06)	(0.29–4.12)	(0.41–4.55)
	Multivariate adjusted RR[b]	0.92	0.69	1.53	0.90
	(95% CI)	(0.39–2.15)	(0.15–3.26)	(0.38–6.18)	(0.18–4.37)
Urban					
Often, sometimes	(Ref.)	1.00	1.00	1.00	1.00
A few, never	Age-adjusted RR	2.29	2.40	2.03	2.48
	(95% CI)	(1.47–3.56)	(1.22–4.73)	(0.93–4.39)	(1.01–6.07)
	Multivariate adjusted RR[b]	2.39	2.63	1.85	2.74
	(95% CI)	(1.47–3.90)	(1.28–5.39)	(0.73–4.68)	(1.04–7.23)

[a] Adjusted for age (10-year age categories), occupation (any kind of occupation, no occupation), educational background (junior college and college or higher, lower than high school), smoking habit (never, past, current), alcohol consumption (never and light, heavy), body mass index (<18.5, 18.5⩽BMI<25, ⩾25), and chronic disease (any, no).

[b] Adjusted for age (10-year age categories), occupation (any kind of occupation, no occupation), educational background (junior college and college or higher, lower than high school), smoking habit (never, past, current), body mass index (<18.5, 18.5⩽BMI<25, ⩾25), and chronic disease (any, no).

in activities, for men, the Tecumseh Community Health Study showed similar findings, i.e., elevated mortality risk associated with low frequency of attendance at meetings of volunteer associations, spectator events (movies, plays, fairs, sports events), and classes or lectures.[4] Welin *et al.*[22] reported that high levels of social, home, and outside home activities protect middle-age men from premature death. Sugisawa *et al.*[9] hypothesized that physical health and health behaviour mediated the effects of social networks and social support on mortality and found that social participation by Japanese elderly, but not by middle-aged people, had direct and indirect effects on mortality linked with functional status and self-rated health. Meanwhile, our finding that the number of meetings with close relatives is less important for men and rural women was consistent with the Tecumseh Community Health Study and the Evans County Cardiovascular Epidemiologic Study[4,5] and that this factor is more important for urban women was consistent with the Alameda County Study.[2] Berkman[23] proposed that social networks might be less associated with mortality in a socially cohesive area. This is one of the interpretations of our observed rural-urban difference. Tamano *et al.*[24] reported finding that Japanese elderly women rely heavily on their relatives, especially their children and that the degree of relationship between them was associated with their subjective happiness and loneliness. Assuming that this finding extends to middle-aged Japanese women, it may provide a plausible interpretation of the elevated RR. These interesting findings, that lack of participation, for men, and lack of meeting close relatives, for women, increased the mortality risk may reflect the characteristics of the social networks of the two sexes. Women's friendships focus on intimacy and disclosure, while men's emphasize sociability and task/activity orientation.[25,26] In other words, men are more likely to make special efforts to foster social relationships through formal organizations and activities. These findings seem to indicate that the lack of crucial social networks for each sex is a particularly strong predictor for mortality. Results from cause-specific deaths gave us suggestive observations. The elevated risk of deaths among men with lack of participation was due to all circulatory system disease, especially cerebrovascular disease, and non-cancer and non-circulatory system disease. For women who lacked meeting close relatives, the elevated risk of deaths was explained by all cancer, cerebrovascular disease, and non-cancer and non-circulatory system disease. Previous studies showed social networks have little or no influence on the risk of coronary heart disease incidence[27] and the protective mechanisms were explained by the fact that social relationship affected survival following the onset of coronary heart disease.[28] Kawachi *el al*.[29] reported socially isolated men were at increased risk of cerebrovascular disease incidence. In terms of cancer incidence, Reynolds *et al.*[3] showed no association for women. Protective effects of social networks on cerebrovascular disease and cancer survival were reported by Vogt *et al.*[30] In general, previous findings indicated that social networks were more important in recovery from chronic conditions than their incidence. Although our data cannot determine which pathways contribute to reducing each mortality risk, it would appear that social networks could improve mortality through counteracting the effects of cerebrovascular disease rather than ischaemic heart disease in the case of Japanese.

Household, friends, religion, and neighbourhood

Although a smaller household size was associated with all-cause mortality risk for men, this significant association did not persist after exclusion of deaths in the first 4 years of the 7-year follow-up period (data not shown). Sorlie *et al.*[31] reported that household size was not significantly associated with multivariate adjusted mortality risk for middle-aged men, while large household size decreased the age-area adjusted mortality risk. This indicated that protective effect of this factor might be questionable. In terms of neighbourhood, we have already reported and discussed the rural-urban difference elsewhere.[13] In general, neighbourhood relationship is more passive and less intimate than relationship with friends and relatives. In rural societies, maintaining good fellowship with one's neighbours is socially desirable and that might lead to this factor becoming a stressor. Friends and religion were not found to have statistically significant effects on the risk of deaths for men and women. These findings were not consistent with the results in the US.[2,4] Our results may be attributable to the use of simple questions to assess individual's social networks. Berkman *et al.*[2] mentioned that it is necessary to use an index for contacts with friends and relatives consisting of three questions, because none of the three questions provided important predictors of mortality alone. This indicates that only a single question, e.g. When you are in need, do you have close friends you can turn to?, might be too simple to detect actual relationships.

Limitations of this study

Some limitations of this study should be pointed out. First, since our baseline survey was conducted by means of a self-administered questionnaire, our baseline data did not include objective data, such as the results of physical and physiological examination or laboratory data. Second, it must be kept in mind that even though we took several potential confounding factors into consideration, other confounding factors, such as stress and quality or functional aspects of relationships, may remain. Third, this study was not designed to observe the effect of changes in social network items and other control variables. Using baseline data alone may have resulted in some misclassifications of exposure variables that would tend to mask associations. Finally, as mentioned above, each of the social network items alone and some covariates may have been too simple to detect actual relationships or to measure actual exposure and this might have led to a wrong estimation of associations between social networks and mortality or misclassification of exposures.

Despite these limitations, this study has some compensating benefits to the extent that it provides meaningful new knowledge for Japanese social networks which predict premature deaths.

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KEY MESSAGES

- Being single for women seems to be an independent risk factor for mortality.
- Lack of participation for men seems to be an independent risk factor for mortality that could account for cerebrovascular diseases but not cancer or ischaemic heart diseases.
- Lack of meeting close relatives for urban women seems to be an independent risk factor for major cause-specific mortality.
- Social networks are important predictors for premature deaths among Japanese.

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