

thermal comfort and energy  
residential environments and physical activity  
effects on mental health  
the challenge of ageing populations

Unfortunately, the housing policy has long been separated from the public health policy in Japan, and as a result, the healthy housing policy is not included in the Healthy Japan 21 plan.

Appropriate housing protects the inhabitants from heat, cold, damp, hazardous pollutants and other risk factors for health<sup>9)</sup>. As the 2003 summer scandal in France indicated<sup>Note</sup>, poor housing affects the vulnerable groups most. It is strongly recommended to integrate the housing policy into the public health policy in order to realize a healthy aged society.

#### ❖ Note

The 2003 European heat wave was one of the hottest summers on record in Europe. The heat wave killed 14,802 French people, mostly elderly. Most homes of them and retirement homes were not equipped with air conditioning.

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## Analysis of the Relationship between Depression and Changes in ADL Status among the Japanese Aged

Shinya Matsuda<sup>1)</sup> and Yoshihisa Fujino<sup>1)</sup>

<sup>1)</sup>Department of Preventive Medicine and Community Health, School of Medicine, University of Occupational and Environmental Health

### Abstract

In 2006 the Ministry of Health, Labor and Welfare (MHLW) has launched the 2006 Health care reform plan. One of the characteristics of this plan is to value the preventive activities. Most of these programs mainly focus to the disease specific symptoms and outcomes such as pain, weakness of muscle, and little attention is paid to the mental depression. In order to evaluate the effect of depressive situation on changes in Activity of Daily Living (ADL) level, we have organized and analyzed a two year's panel data (2004–2005) that contains about 1800 aged living in a city of western Japan. For evaluation of ADL level and depression status, Typology of Aged with Illustration (TAI) and Geriatric Depression Scale five item version (GDS5) were used, respectively. After evaluating the results of descriptive analyses, logistic regression analyses were conducted in order to analyze the factors associated with aggravation of ADL levels between 2004 and 2005. The results indicated that depressive status has significant influence on changes in ADL independency status, that is, the person with higher depression situation showed the higher possibility of worsening the ADL level. higher depression situation were related to the worsening of mobility (OR=0.749, 95%CI=0.655–0.857), mental status (OR=0.606, 95%CI=0.489–0.750), eating (OR=0.603, 95%CI=0.458–0.793), toileting (OR=0.564, 95%CI=0.456–0.698), and bathing (OR=0.647, 95%CI=0.551–0.760). The results of our study have suggested that the health promotion activities for the aged must pay enough attention for the depression problem in order to improve and to maintain their ADL independency.

**Key words:** depression, ADL, aged, prevention, Japan

### ❖ Introduction

Japan has a universal coverage of public pension, medical insurance and Activity of Daily Living (ADL) care insurance (Long term care insurance; LTCI). Along with the rapid ageing of society, today, the aged are responsible for one half of medical expenditures. For example, the medical expenditures for the aged was 16.5 trillion USD (1USD=100 JY) in 2004<sup>1)</sup>.

In addition to the medical expenditures, the aged used 50 trillion USD for pension<sup>2)</sup>, and 5.6 trillion for LTCI coverage<sup>3)</sup>. These expenditures for social security system will expand more rapidly within the coming 10 years, because the post-war baby boomers will enter their third age.

Thus, it is an urgent task for the Japanese government to re-organize the social security system in order to make it sustainable under the coming highly aged society. In 2006 the Ministry of Health, Labor and Welfare (MHLW) has launched the 2006 Health Care Reform Plan<sup>4)</sup>. One of the characteristics of this plan is to value the preventive activities. As a main program of health promotion, for example, "Health checkups and healthcare advice with a particular focus on the metabolic syndrome" program has been intro-

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Correspondence: S. Matsuda, Department of Preventive Medicine and Community Health, School of Medicine, University of Occupational and Environmental Health, Iseigaoka 1-1, Yahatanishi, Kitakyushu 807-8555, Japan  
e-mail: smatsuda@med.uoeh-u.ac.jp

duced from 2008. All public health insurers have to organize health check-up and the following health promotion programs for the insured over 40 years old. The main target of screening is "Metabolic syndrome". If an insured is evaluated as high risk, he/she must follow a standardized disease management program that is offered by the health support organization contracted with the insurers.

For LTCI, the special program for maintenance and amelioration of ADL status has been introduced<sup>5,6</sup>. The slightly frail aged has to receive the preventive ADL services. As the osteo-muscular problems i.e., knee-joint disorders, are the most important reasons for them to receive LTCI services, the physical fitness program is included in the new scheme.

Most of these programs mainly focus to the disease specific symptoms and outcomes such as pain, weakness of muscle, and little attention is paid to the mental depression. Chapman et al have indicated that depressive disorders assume an important role in the etiology, course and outcomes associated with chronic diseases<sup>7</sup>. Based on the results of previous articles, we have hypothesized that the same relationship may exist between depression and ADL independency levels among the Japanese aged. To test this hypothesis, we have organized a panel data that contains about 1800 aged living in a community of western Japan. In this article, we present the results of this study.

### ❖ Studied Population and Method

The population studied was inhabitants of a city of Fukuoka prefecture. The 2,000 inhabitants more than 65 years old were randomly selected from citizen registration by the city council. We have received data from 1,821 peoples with sufficient information both for 2004 and 2005. There was no case of rejection in 2004. Reasons of exclusion in 2005 were as following; 36 were already institutionalized, 27 moved outside the city, 23 died and 57 were due to insufficient information. There were no significant differences between the included and excluded persons for the distribution of age and sex distribution.

The trained interviewers visited to chosen inhabitants and gathered information using a structured questionnaire from June to September 2004 and 2005. The questionnaire composes of items regarding demographic data (sex, age, address), health status,

ADL (Typology of Aged with Illustration: TAI<sup>8,9</sup>), and Depression status measured by GDS5 (Geriatric Depression Scale five item version)<sup>10</sup>.

After evaluating the results of descriptive analyses, we conducted a series of logistic regression analysis in order to clarify the factors associated with aggravation of ADL levels between 2004 and 2005. Independent variables and dependent variables are as follow:

#### *Independent variables*

Age category:

0 = 65-74 years old, 1 = 75 years old and more

Sex:

0 = Male, 1 = Female

CVD (Cerebro-vascular diseases):

0 = No disability due to CVD,

1 = Disability due to CVD

OMD (Osteo-muscular diseases):

0 = No OMD, 1 = Existence of OMD

Other diseases:

0 = No other diseases,

1 = Existence of other diseases

Depression score:

0 = highest level of depression,

5 = lowest level of depression

#### *Dependent variable*

Change in each of TAI score (Mobility, Mental status, Eating, Toileting, Bathing, House affairs):

0 = maintained/improved, 1 = worsened

The name of studied people was excluded from the data for analysis in order to assure the privacy.

The statistical analyses were conducted by SPSS 14.0J.

The ethical board of University of Occupational and Environmental Health approved this study and the written consent was obtained from all participants after the explanation of objectives of study by document.

### ❖ Results

Table 1 shows the demographic status of studied population. The mean and standard deviation were  $74.3 \pm 5.9$  for male,  $74.3 \pm 5.9$  for female and  $74.3 \pm 5.9$  for total. For the age distribution, persons in 70s were the largest (1021, 56.1%), followed by 60s (414, 22.7%), 80s (347, 19.1%) and 90s (39, 2.1%). The percentage of female increased after 80s (more than

**Table 1** Sex and age distribution of studied population

Age category		65-69	70-79	80-89	90-	Total
Male	N	177	434	126	13	750
	% age	23.6	57.9	16.8	1.7	100.0
	% sex	42.8	42.5	36.3	33.3	41.2
Female	N	237	587	221	26	1071
	% age	22.1	54.8	20.6	2.4	100.0
	% sex	57.2	57.5	63.7	66.7	58.8
Total	N	414	1021	347	39	1821
	% age	22.7	56.1	19.1	2.1	100.0
	% sex	100.0	100.0	100.0	100.0	100.0

**Table 2** Prevalence rates of chronic diseases by sex

		CVA	HD	OMD	Others	Total
Male	N	83	116	132	497	750
	%	11.1	15.5	17.6	66.3	100.0
Female	N	83	116	132	497	750
	%	5.5	15.3	36.6	66.9	100.0
Total	N	83	116	132	497	750
	%	7.8	15.4	28.8	66.7	100.0

CVA: Cerebro-vascular diseases, HD: Heart diseases, OMD: Osteo-muscular diseases.

60%).

Table 2 shows the prevalence rate of chronic diseases. The cerebro-vascular diseases were more dominant among the male elderly (11.1% vs 5.5%). On the contrary, the osteo-muscular diseases were more dominant among the female elderly (36.6% vs 17.6%). About 15% of both sex had the heart diseases and 67% had other diseases such as hypertension and diabetes mellitus.

Table 3 shows the distribution of ADL level measured by TAI. Each item in the TAI has six hierarchical status (5 to 0), representing levels of disability in each domain. Five represents no disability and 0 represents extreme disability. For mobility level, 1420 (78.0%) persons were categorized into "5", 288 (15.8%) were "4", 93 (5.1%) were "3", 9 (0.5%) were "2", 7 (0.4%) were "1" and 4 (0.2%) were "0". Male persons showed a higher percentage of level 5 (83.6% vs 74.0%).

For mental status, 1762 (96.8%) persons were categorized into "5", 43 (2.4%) were "4", 6 (0.3%) were

"3", 4 (0.2%) were "2", 3 (0.2%) were "1" and 3 (0.2%) were "0". There was no apparent sex difference in distribution.

For eating independence, 1790 (98.3%) persons were categorized into "5", 20 (1.1%) were "4", 4 (0.2%) were "3", 3 (0.2%) were "2", 0 (0.0%) were "1" and 4 (0.2%) were "0". There was no apparent sex difference in distribution.

For toileting independence, 1741 (95.6%) persons were categorized into "5", 56 (3.1%) were "4", 11 (0.6%) were "3", 6 (0.3%) were "2", 4 (0.2%) were "1" and 3 (0.2%) were "0". There was no apparent sex difference in distribution.

For bathing independency, 1629 (89.1%) persons were categorized into "5", 142 (7.8%) were "4", 30 (1.6%) were "3", 11 (0.6%) were "2", 6 (0.3%) were "1" and 3 (0.2%) were "0". There was no apparent sex difference in distribution.

For independency of house affairs, 1052 (58.3%) persons were categorized into "5", 194 (10.7%) were "4", 245 (13.5%) were "3", 32 (1.8%)

**Table 3** ADL independency level of studied population

			0	1	2	3	4	5	Total
Mobility level	Male	N	2	5	3	35	78	627	750
		%	0.3	0.7	0.4	4.7	10.4	83.6	100.0
	Female	N	2	2	6	58	210	793	1071
		%	0.2	0.2	0.6	5.4	19.6	74.0	100.0
	Total	N	4	7	9	93	288	1420	1821
		%	0.2	0.4	0.5	5.1	15.8	78.0	100.0
Mental status	Male	N	1	0	0	2	24	723	750
		%	0.1	0.0	0.0	0.3	3.2	96.4	100.0
	Female	N	2	3	4	4	19	1039	1071
		%	0.2	0.3	0.4	0.4	1.8	97.0	100.0
	Total	N	3	3	4	6	43	1762	1821
		%	0.2	0.2	0.2	0.3	2.4	96.8	100.0
Eating independence	Male	N	2	0	2	3	12	731	750
		%	0.3	0.0	0.3	0.4	1.6	97.5	100.0
	Female	N	2	0	1	1	8	1059	1071
		%	0.2	0.0	0.1	0.1	0.7	98.9	100.0
	Total	N	4	0	3	4	20	1790	1821
		%	0.2	0.0	0.2	0.2	1.1	98.3	100.0
Toileting independence	Male	N	1	3	2	5	28	711	750
		%	0.1	0.4	0.3	0.7	3.7	94.8	100.0
	Female	N	2	1	4	6	28	1030	1071
		%	0.2	0.1	0.4	0.6	2.6	96.2	100.0
	Total	N	3	4	6	11	56	1741	1821
		%	0.2	0.2	0.3	0.6	3.1	95.6	100.0
Bathing independence	Male	N	1	5	2	14	53	675	750
		%	0.1	0.7	0.3	1.9	7.1	90.0	100.0
	Female	N	2	1	9	16	89	954	1071
		%	0.2	0.1	0.8	1.5	8.3	89.1	100.0
	Total	N	3	6	11	30	142	1629	1821
		%	0.2	0.3	0.6	1.6	7.8	89.5	100.0
Independence of housing affairs	Male	N	7	240	14	184	68	237	750
		%	0.9	32.0	1.9	24.5	9.1	31.6	100.0
	Female	N	7	34	18	61	126	825	1071
		%	0.7	3.2	1.7	5.7	11.8	77.0	100.0
	Total	N	14	274	32	245	194	1062	1821
		%	0.8	15.0	1.8	13.5	10.7	58.3	100.0

were "2", 274 (15.0%) were "1" and 14 (0.8%) were "0". There was an apparent sex difference in independency level. Only 31.6% of male persons were categorized into level 5.

Table 4 shows the changes in each of ADL level between 2004 and 2005. For mobility, 11.1% of level 5 and 7.6% of level 4 decreased in independency. For

house affairs, 12.0% of level 5, 12.9% of level 4, 18.0% of level 3 and 15.6% of level 2 decreased in independency. For other ADL items, such as mental status, eating, toileting and bathing, most of studied elderly kept their independency level between the two years.

Table 5 shows the results of depression score. On

**Table 4** Changes of ADL level between 2004 and 2005

		0	1	2	3	4	5	Total
Mobility level in 2004								
Maintained/Improved	N	4	5	9	89	266	1263	1636
	%	100.0	71.4	100.0	95.7	92.4	88.9	89.8
Worsened	N	0	2	0	4	22	157	185
	%	0.0	28.6	0.0	4.3	7.6	11.1	10.2
Mental status in 2004								
Maintained/Improved	N	3	3	3	6	40	1721	1776
	%	100.0	100.0	75.0	100.0	93.0	97.7	97.5
Worsened	N	0	0	1	0	3	41	45
	%	0.0	0.0	25.0	0.0	7.0	2.3	2.5
Eating independence in 2004								
Maintained/Improved	N	4	0	3	4	20	1765	1796
	%	100.0	0.0	100.0	100.0	100.0	98.6	98.6
Worsened	N	0	0	0	0	0	25	25
	%	0.0	0.0	0.0	0.0	0.0	1.4	1.4
Toileting independence in 2004								
Maintained/Improved	N	3	4	4	9	53	1703	1776
	%	100.0	100.0	66.7	81.8	94.6	97.8	97.5
Worsened	N	0	0	2	2	3	38	45
	%	0.0	0.0	33.3	18.2	5.4	2.2	2.5
Bathing independence in 2004								
Maintained/Improved	N	3	6	8	27	129	1548	1721
	%	100.0	100.0	72.7	90.0	90.8	95.0	94.5
Worsened	N	0	0	3	3	13	81	100
	%	0.0	0.0	27.3	10.0	9.2	5.0	5.5
Independence of housing affairs								
Maintained/Improved	N	14	270	27	201	169	935	1616
	%	100.0	98.5	84.4	82.0	87.1	88.0	88.7
Worsened	N	0	4	5	44	25	127	205
	%	0.0	1.5	15.6	18.0	12.9	12.0	11.3

**Table 5** Depression score of the studied population

	Mean	SD	Min	Max
Male	4.4	0.9	0	5
Female	4.3	1.0	0	5
Total	4.3	1.0	0	5

average, the studied persons were in relatively good conditions. There were no apparent sex differences in the scores.

Table 6 shows the comparison of score of depression score stratified by existence of CVA, heart dis-

eases, OMD and other diseases. The depressive status were more apparent for the persons with CVA ( $p < 0.001$ ; Mann-Whitney's U), heart diseases ( $p = 0.002$ ), and OMD ( $p < 0.001$ ).

Table 7 shows the results of multivariate logistic regression analysis about the factors associated with aggravation of ADL level. For mobility level, persons  $\geq 75$  years old (OR=1.663, 95%CI=1.333-2.076), with CVD (OR=1.872, 95%CI=1.130-3.101), OMD (OR=1.932, 95%CI=1.394-2.676), other diseases (OR=2.102, 95%CI=1.427-3.097) and higher depression situation (OR=0.749, 95%CI=0.655-0.857) showed a significantly higher probability of de-

**Table 6** Depression score stratified by existence of diseases

		N	Average rank	Rank sum	Mann-Whitney's U	p
CVA	No	1679	926.6	1555743.0	93035.0	0.000
	Yes	142	726.7	103188.0		
HD	No	1541	925.7	1426498.5	193092.5	0.002
	Yes	280	830.1	232432.5		
OMD	No	1297	941.1	1220582.0	300799.0	0.000
	Yes	524	836.5	438349.0		
Other diseases	No	607	955.3	579867.0	341559.0	0.004
	Yes	1214	888.9	1079064.0		

CVA: Cerebro-vascular diseases, HD: Heart diseases, OMD: Osteo-muscular diseases.

ing independency.

For mental status, persons  $\geq 75$  years old (OR=3.672, 95%CI=1.796–7.511) and with higher depressive situation (OR=0.606, 95%CI=0.489–0.750) showed a significantly higher probability of decreasing independency.

For eating independency, persons with CVD (OR=3.719, 95%CI=1.507–9.178), higher depressive situation (OR=0.603, 95%CI=0.458–0.793), and  $\geq 75$  years old (OR=2.938, 95%CI=1.151–7.501) showed a significantly higher probability of decreasing independency.

For toileting independency, persons with CVD (OR=2.814, 95%CI=1.355–5.847), higher depressive situation (OR=0.564, 95%CI=0.456–0.698), and  $\geq 75$  years old (OR=4.540, 95%CI=2.079–9.913) showed a significantly higher probability of decreasing independency.

For bathing independency, persons with CVD (OR=2.008, 95%CI=1.095–3.683), heart diseases (OR=1.915, 95%CI=1.188–3.086), OMD (OR=1.884, 95%CI=1.228–2.889), higher depressive situation (OR=0.647, 95%CI=0.551–0.760), and  $\geq 75$  years old (OR=2.152, 95%CI=1.367–3.388) showed a significantly higher probability of decreasing independency.

For independency of housing affairs, persons with OMD (OR=1.638, 95%CI=1.193–2.248),  $\geq 75$  years old (OR=2.072, 95%CI=1.527–2.811) and male (OR=0.726, 95%CI=0.535–0.985) showed a significantly higher probability of decreasing independency.

## ❖ Discussion

The present results have indicated that people with chronic disease condition, such as disability due to CVA and OMD show significantly higher depressive status. The most interesting finding of our study is that the depressive status has significant influence on changes in ADL independency status, that is, the person with higher depression situation showed the higher possibility of worsening the ADL level.

These findings are consistent with most of the previous literatures. Husaini and Moors reported that arthritis disability was significantly influential to depression and life satisfaction among the elderly<sup>11</sup>. Another literature has indicated that depression and/or anxiety are among the most commonly reported concerns by persons with arthritis<sup>12</sup>.

For stroke, there are several reports indicating that persons with depressive symptoms show statistically significant higher possibility to have a stroke. In addition to being a predictor of stroke, depression commonly develops after a stroke. For example, Berg et al clarified that more than half of patients experiencing a stroke reported depressive symptoms within 18 months of having a stroke<sup>13</sup>. Furthermore, post-stroke depression has been associated with increased mortality up to two years following the stroke<sup>14</sup>.

Increased rate of depression have consistently been associated with diabetes<sup>15</sup>. Depressive symptoms have been associated with diabetes-related complication<sup>15</sup>, and social adaptation of diabetic patients<sup>16</sup>.

As these literatures have indicated, there would be no doubt that depressive disorders assume an impor-

**Table 7** Factors associated with worsening of mobility level

		Beta	SE	Wald	OR	95% of OR
Mobility	Age category	0.509	0.113	20.285	1.663	1.333–2.076
	CVD	0.627	0.258	5.923	1.872	1.130–3.101
	OMD	0.658	0.166	15.679	1.932	1.394–2.676
	Other Diseases	0.743	0.198	14.116	2.102	1.427–3.097
	Depression score	-0.289	0.069	17.795	0.749	0.655–0.857
Mental status	Depression score	-0.501	0.109	21.143	0.606	0.489–0.750
	Age category	1.301	0.365	12.698	3.672	1.796–7.511
Eating	CVD	1.314	0.461	8.124	3.719	1.507–9.178
	Depression score	-0.506	0.140	13.068	0.603	0.458–0.793
	Age category	1.078	0.478	5.079	2.938	1.151–7.501
Toileting	CVD	1.035	0.373	7.693	2.814	1.355–5.847
	Depression score	-0.572	0.109	27.771	0.564	0.456–0.698
	Age category	1.513	0.398	14.418	4.540	2.079–9.913
Bathing	CVD	0.697	0.309	5.075	2.008	1.095–3.683
	Heart diseases	0.650	0.243	7.116	1.915	1.188–3.086
	OMD	0.633	0.218	8.426	1.884	1.228–2.889
	Depression score	-0.436	0.082	28.223	0.647	0.551–0.760
	Age category	0.766	0.231	10.959	2.152	1.367–3.388
House affairs	OMD	0.493	0.162	9.319	1.638	1.193–2.248
	Age category	0.729	0.156	21.909	2.072	1.527–2.811
	Sex	-0.321	0.156	4.218	0.726	0.535–0.985

**Independent variables**

- Age category: 0: 65–74 years old, 1: 75 years old and more  
 Sex: 0: Male, 1: Female  
 CVD (Cerebro-vascular diseases): 0: No disability due to CVD, 1: Disability due to CVD  
 OMD (Osteo-muscular diseases): 0: No OMD, 1: Existence of OMD  
 Other diseases: 0: No other diseases, 1: Existence of other disease  
 Depression score: 0: lowest level of depression, 4: highest level of depression

**Dependent variable**

- Change in each of TAI score: Mobility, Mental status, Eating, Toileting, Bathing, House affairs  
 Score: 0: lowest, 5: highest

tant role in the etiology, course and outcomes associated with chronic diseases.

The Health Care Reform Plan 2006 in Japan values preventive activities. However, most of programs under the new scheme focus to the physically functional improvement and do not pay enough attention to depression and/or depressive symptoms. Although a positive effect of physical activity on mental status have been reported<sup>17)</sup>, more interventions such as depression prevention program will be needed.

Ageing is the process of losing. Along with time, the aged peoples lose their health, family members, role in occupational and social life. All these events

of losing would cause the depression or depressive symptoms for the aged. In order to realize an active aged society, thus, it is necessary to implement the more integrated programs that cover whole life aspect of the aged. Especially we think that necessary is the program facilitating the social participation of the aged. Along with the large scale intra-immigration along with the economic development after the Second World War, most of the Japanese communities have lost the social tie. Expansion of nuclear family has deprived the traditional familial role of the aged.

Japan belongs to the high suicide countries around the world. Especially the suicide rate is very



high among the aged. It is well known that there are depression or depressive conditions behind most of the suicide cases. Depression caused by the losing process may contribute to the high suicide prevalence among the Japanese aged.

Therefore, we have to re-create the opportunities of social participation for the aged. Under the Confucianism tradition, the Japanese values the work. It is reported that the Japanese aged have very high willingness to continue to work<sup>18</sup>). The economic aspect is not the most important reason for them. They want to work in order to keep the relationship with the society. Crimmins et al have showed that the working aged people keep their physical and mental health compared with the non-working aged<sup>19</sup>).

In order to promote physical and mental health of the aged, it will be one reasonable solution to extend the retirement age up to 70 years old or more drastically to abandon the retirement age<sup>20</sup>). Most of the employees are reluctant to this proposal, because it may mean the higher labor cost relative to productivity. It will be necessary to re-organize the wage structure and labor contract that permit to balance cost and productivity.

Another solution is to create small works for the aged in the community, such as gardening, house-keeping, teacher-assistant in the public school, assistant work in the agricultural sector. We call this policy as "new work-fare program" and it is beginning in some communities and by NPOs as voluntary basis. In fact, most of the programs indicated that the participating aged people are becoming more active.

There are some limitations for this study. First, as we used self-evaluation on diagnosis and depression situation, the existence of information bias cannot be excluded. For example, depressive person might evaluate their ADL level less than the objective level. Second, we did not obtain information on a number of important possible confounding and pathway variables, including smoking, drinking, physical exercise, nutritional intake, economic status, education status, marital condition and formal/informal care. For example, the economic situation is one of the most anxious issues among the aged and might be associated with depression and accessibility of ADL and formal care. This limited adjustment weakens the conclusion. Third, the study population is relatively small to derive a definitive conclusion. These limitations must be taken into account for evaluation of the

present study.

In conclusion, the results of our study have suggested that the depressive status has significant influence on changes in ADL independency status. The health promotion activities for the aged must pay enough attention for the depression problem in order to improve and to maintain their ADL independency.

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## Prospective study of living arrangement by the ability to receive informal care and survival among Japanese elderly

Yoshihisa Fujino\*, Shinya Matsuda

Department of Preventive Medicine and Community Health, University of Occupational and Environmental Health, Japan, 1-1, Iseigaoka, Yahatanishiku, Kitakyushu, 807-8555, Japan

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### ABSTRACT

**Objectives.** In light of recent concerns regarding informal care, we examined the association between living arrangement and survival among elderly Japanese, with living arrangement measured in terms of the ability to receive informal care from the immediate family.

**Methods.** A total of 3000 subjects aged 60 years or older were randomly recruited in Yukuhashi City, Japan, in 2002, of whom 2773 provided complete information for analysis. A trained local welfare commissioner visited the subjects annually from 2002 to 2007 and collected information concerning living arrangements, mobility status, medical status, and use of long-term care insurance service. During the 5 years of follow-up, 381 deaths were recorded.

**Results.** Living arrangement was not associated with survival among elderly women. In contrast, compared with men living with others able to provide care throughout the day, mortality was higher for those living with others unable to provide sufficient care due to illness or infirmity; those living with others receiving long-term care insurance service; and those living alone without support from family or friends (multivariable hazard ratio=1.40, 95% Confidence Interval 0.94–2.09; hazard ratio=1.89, 95% Confidence Interval 1.07–3.34; and hazard ratio=5.76, 95% Confidence Interval 2.16–15.36; respectively).

**Conclusion.** We found that living arrangement as classified by the ability to receive informal care affects survival among elderly men.

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### Introduction

The increased life expectancy of Japanese, which averaged 83 years (male 79, female 86) in 2006 (World Health Organization, 2008) and is now the longest in the world, probably owes to long-term improvements in social environment, such as in the economy, hygiene, education, peacekeeping, and security. Nevertheless, the increase in expectancy has been accompanied by social problems related to the aging of the population.

Informal care for the elderly is thus an important public health concern, particularly with regard to service delivery, care costs, care provision, and long-term care insurance. Japan introduced long-term care insurance in 2000 (General Affairs Division et al., 2002), with an initial number of elderly certified to receive long-term care from of 1.5 million, increasing to 3.2 million in 2005 (Statistics and Information Department et al., 2006a, 2006b). Further, a declining fertility rate has increased the ratio of nuclear families among the elderly population, with families of two increasing from 20% in 1988 to 30% in 2006, and elderly people living alone from 15% of all elderly aged 65 or over in 1988 to 22% in 2006 (Statistics and Information Department et al., 2006a, 2006b).

Despite public concern about the effect of living arrangements on the elderly and the ability to receive informal care, we are unaware of any study that has examined the health effects of living arrangements in these terms. Of the few studies which examining the effect of living arrangement on health (Brown et al., 2002, Davis et al., 1997, Davis et al., 1992, Gliksman et al., 1995, Iliffe et al., 1992, Joung et al., 1994, Lawton et al., 1984, Magaziner et al., 1988, Murata et al., 2005, Sarwari et al., 1998), only a few were prospective (Davis et al., 1997, Davis et al., 1992, Iliffe et al., 1992, Joung et al., 1994, Magaziner et al., 1988, Sarwari et al., 1998), and results have been inconsistent. Moreover, only one study has been conducted among Japanese elderly, which showed that aged Japanese women living alone were better off in terms of mortality than those in multi-generation households (Murata et al., 2005).

Here, we prospectively examined the association between living arrangement and survival among elderly Japanese, with living arrangement measured in terms of the ability to receive informal care from the immediate family.

### Material and methods

#### Study subjects

A total of 3000 subjects were randomly identified from resident registry data held by the municipal office of Yukuhashi City, Fukuoka

\* Corresponding author. Fax: +81 93 603 4307.  
E-mail address: [zenq@med.uoeh-u.ac.jp](mailto:zenq@med.uoeh-u.ac.jp) (Y. Fujino).

	Category	Explanation
Living with others	Living with others who provide care throughout the day	Subject lives with other(s) who usually stay at home throughout the day and who is potentially able to provide care if needed.
	Living with others who cannot provide sufficient care due to illness or infirmity	Subject live with other(s) who usually stay at home but cannot provide sufficient care due to illness or infirmity.
	Living with others who cannot provide sufficient care due to a job	Subject lives with other(s) who works either full- or part-time. Subject usually stays at home alone for a certain time per day.
	Living with another who is receiving long-term care insurance service	This category particularly indicates a "family of two", in which either a spouse or nonspouse is receiving long-term care insurance service, regardless of subject's receipt himself/herself of long-term care insurance service.
Living alone	Living alone with frequent support from family and friends	Family and friends frequently visit and provide support to a subject who lives alone.
	Living alone without support from family or friends	Subject lives alone, but is rarely visited by family or friends.

Fig. 1. Living arrangement categories.

Prefecture, Japan in 2002, representing approximately 10% of the elderly aged 60 years or older across five school districts. Enrollment was restricted to subjects living at home, and excluded those living in nursing homes. Twenty-seven subjects declined participation in the study and 200 were excluded owing to extended hospitalization or stay in a nursing home. Finally, 2773 (1178 males and 1595 females) provided complete information for analysis. A trained local welfare

commissioner visited the subject at home and collected information using a questionnaire administered by face-to-face interview. Information was collected annually from 2002 to 2006. Information about the use of long-term care insurance was provided by the city municipal office, and the vital status of each participant was checked using data held at the municipal office. Follow-up surveys on survival were conducted until August 2007. Participants were censored on the

**Table 1**  
Characteristics of participants by year (Yukuhashi City, Japan, 2002–2006)

	Men					Women				
	Baseline (2002)	2nd wave (2003)	3rd wave (2004)	4th wave (2005)	5th wave (2006)	Baseline (2002)	2nd wave (2003)	3rd wave (2004)	4th wave (2005)	5th wave (2006)
Number of subjects	1178	1155	1096	1060	985	1595	1584	1545	1529	1468
Living arrangement (%)										
Living with others who provide care throughout the day	82	79	78	81	76	55	49	46	57	49
Living with others who cannot provide sufficient care due to illness, or infirmity	8	10	11	8	10	16	17	18	11	13
Living with others who cannot provide sufficient care due to job	4	4	4	3	4	11	11	12	11	13
Living with others who were receiving long-term care insurance service	2	2	3	3	4	3	4	4	3	5
Living alone with frequent support from family and friends	4	4	5	5	4	14	18	19	17	17
Living alone without support from family or friends	0 <sup>a</sup>	1	1	0 <sup>a</sup>	1	1	1	1	2	3
Mobility <sup>b</sup> (%)										
Level 5	87	86	83	83	83	80	77	72	73	75
Level 4	8	8	11	12	8	13	16	20	21	12
Level 3	4	5	5	4	5	5	5	7	5	9
Level 2	0 <sup>a</sup>	1	0 <sup>a</sup>	0 <sup>a</sup>	2	1	1	1	1	2
Level 1	0 <sup>a</sup>	0 <sup>a</sup>	1	0 <sup>a</sup>	1	1	1	1	0 <sup>a</sup>	1
Level 0	0 <sup>a</sup>	0 <sup>a</sup>	0 <sup>a</sup>	0 <sup>a</sup>	1	0 <sup>a</sup>	0 <sup>a</sup>	0 <sup>a</sup>	0 <sup>a</sup>	1
Medical status (%)										
In hospital	0 <sup>a</sup>	0 <sup>a</sup>	0 <sup>a</sup>	0 <sup>a</sup>	1	0 <sup>a</sup>	0 <sup>a</sup>	0 <sup>a</sup>	0 <sup>a</sup>	1
Receiving periodical outpatient treatment	64	68	70	60	65	68	74	78	68	68
Without any medical care	36	32	30	40	34	32	26	22	32	31
Use of long-term care insurance (%)	5	7	8	10	11	11	12	13	16	19

<sup>a</sup> Less than 1%, but not zero.

<sup>b</sup> level 5, ability of the elder to climb stairs without aid or assistive devices; level 4, cannot climb stairs without aid but can walk on flat surface without aid or assistive devices; level 3, cannot walk on a flat surface without aid, but can move around using assistive devices and perform transfer independently while seated; level 2, cannot either move around or transfer while seated using assistive device or aid from the others, but can sit up and maintain seated position; level 1, cannot either sit up or maintain seated position but can roll over on the bed without aid; and level 0, cannot roll over on a bed while lying without aid.

**Table 2**  
Baseline characteristics according to living arrangements (Yokohashi City, Japan, in 2002)

	Men					Women						
	Living with others who provide care throughout the day	Living with others who cannot provide sufficient care due to illness, or infirmity	Living with others who cannot provide sufficient care due to job	Living with others who were receiving long-term care insurance service	Living alone with frequent support from family and friends	Living alone without support from family or friends	Living with others who provide care throughout the day	Living with others who cannot provide sufficient care due to illness, or infirmity	Living with others who cannot provide sufficient care due to job	Living with others who were receiving long-term care insurance service	Living alone with frequent support from family and friends	Living alone without support from family or friends
Number of subjects	963	97	45	21	47	5	879	249	82	44	227	14
Age mean	72.3	76.2	74.7	81.0	77.3	69.2	73.4	72.5	74.7	76.2	75.7	74.0
SD	5.7	6.3	7.8	6.4	6.8	4.4	6.8	6.2	7.1	7.1	6.3	6.2
Mobility <sup>a</sup> (%)												
Level 5	91	62	80	43	72	100	85	83	74	55	71	64
Level 4	6	19	7	29	15	0	10	11	16	34	22	21
Level 3	2	17	13	14	11	0	4	4	9	2	7	7
Level 2	0 <sup>b</sup>	0	0	5	9	0	0 <sup>b</sup>	1	0	7	0 <sup>b</sup>	0
Level 1	0	1	0	5	2	0	0 <sup>b</sup>	1	1	0	0	0
Level 0	0 <sup>b</sup>	2	0	5	0	0	0 <sup>b</sup>	0 <sup>b</sup>	0	2	0	7
Medical status (%)												
In hospital	0 <sup>b</sup>	0	0	5	2	0	0 <sup>b</sup>	0	0	0	0	0
Receiving periodical outpatient treatment	61	79	67	86	72	40	62	72	74	68	80	71
Without any medical care	39	21	33	10	26	60	37	28	26	32	20	29
Use of Long-term Care Insurance (%)	2	11	7	38	9	0	4	5	5	30	11	0

<sup>a</sup> Level 5, ability of the elder to climb stairs without aid or assistive devices; level 4, cannot climb stairs without aid but can walk on flat surface without aid or assistive devices; level 3, cannot walk on a flat surface without aid, but can move around using assistive devices and perform transfer independently while seated; level 2, cannot either move around or transfer while seated using assistive device or aid from the others, but can sit up and maintain seated position; level 1, cannot either sit up or maintain seated position but can roll over on the bed without aid; and level 0, cannot roll over on a bed while lying without aid.

<sup>b</sup> Less than 1%, but not zero.

date of death or 31 August 2007, whichever came first, giving 11639 person-years (4830 males and 6810 females) of follow-up. During the 5 years of follow-up, 381 deaths (225 males and 156 females) were recorded.

Informed consent is obtained from the participants and the study is approved by the Ethics Committee of University of Occupational and Environmental Health, Japan.

#### Measurement

Living arrangement categories used in this study are shown in Fig. 1. Living arrangements were categorized into six groups by the ability to receive informal care from family members, namely living alone without support from family or friends; living alone with frequent support from family and friends; living with others who were receiving long-term care insurance service; living with others who cannot provide sufficient care due to a job; living with others who cannot provide sufficient care due to illness or infirmity; and living with others able to provide care throughout the day.

Mobility status was measured according to the Typology of the Aged with Illustrations, a validated instrument for the measurement

of elderly function (Okochi, 2005, Okochi et al., 2005a, 2005b, Takahashi et al., 2001), as follows: level 5, able to climb stairs without aid or assistive devices; level 4, cannot climb stairs without aid but can walk on flat surfaces without aid or assistive devices; level 3, cannot walk on a flat surface without aid, but can move around using assistive devices and change position independently while seated; level 2, cannot move around or transfer while seated using an assistive device or aid from others, but can sit up and maintain a seated position; level 1, cannot sit up or maintain a seated position but can roll over on bed without aid; and level 0, cannot roll over on a bed while lying without aid.

Medical status was categorized into three groups: not receiving medical care; receiving periodic outpatient treatment; and hospitalized.

#### Statistical analysis

Sex-specific hazard ratios (HR) were estimated by an extended Cox model with time-dependent variables (Cox and Oakes, 1984, Kleinbaum, 2005). We used three models: age-adjusted model included living arrangement and age; model 1 included age, mobility and medical status; model 2 included age, mobility, medical status, and

**Table 3**  
Hazard ratios of living arrangement for mortality among men (Yukuhashi City, Japan, 2002–2007)

	Person year	Number of deaths	Death rate <sup>a</sup>	Age-adjusted HR			Model 1 <sup>b</sup>			Model 2 <sup>c</sup>					
				HR	95% CI	p	HR	95% CI	p	HR	95% CI	p			
Total	4830	225	47												
Living with others who provide care throughout the day	3888	149	38	Reference			Reference				Reference				
Living with others who cannot provide sufficient care due to illness, or infirmity	435	33	76	1.52	1.03	2.24	0.04	1.40	0.94	2.09	0.10	1.39	0.93	2.07	0.11
Living with others who cannot provide sufficient care due to job	177	12	68	1.42	0.78	2.58	0.25	1.32	0.72	2.42	0.36	1.17	0.64	2.15	0.61
Living with another who is receiving long-term care insurance service	110	15	137	1.87	1.08	3.24	0.03	1.89	1.07	3.34	0.03	1.47	0.82	2.64	0.19
Living alone with frequent support from family and friends	198	11	56	1.14	0.61	2.11	0.68	1.09	0.58	2.02	0.79	1.08	0.58	2.01	0.81
Living alone without support from family or friends	22	5	230	6.37	2.60	15.59	<0.01	5.76	2.16	15.36	<0.01	6.29	2.35	16.83	<0.01
Mobility <sup>d</sup> ≥ level 4	4577	182	40												
Living with others who provide care throughout the day	3763	136	36	Reference				Reference				Reference			
Living with others who cannot provide sufficient care due to illness, or infirmity	367	21	57	1.27	0.80	2.04	0.32	1.12	0.69	1.80	0.65	1.07	0.66	1.74	0.77
Living with others who cannot provide sufficient care due to job	154	8	52	1.32	0.64	2.71	0.45	1.38	0.67	2.83	0.38	1.24	0.60	2.55	0.56
Living with another who is receiving long-term care insurance service	90	7	78	0.90	0.41	1.96	0.79	0.82	0.37	1.84	0.63	0.65	0.28	1.47	0.30
Living alone with frequent support from family and friends	183	7	38	0.93	0.43	2.00	0.86	0.85	0.39	1.83	0.67	0.87	0.41	1.88	0.73
Living alone without support from family or friends	20	3	147	4.16	1.32	13.16	0.02	3.93	1.24	12.50	0.02	4.86	1.53	15.40	<0.01
Mobility <sup>d</sup> < level 3	3	252	43	171											
Living with others who provide care throughout the day	125	13	104	Reference				Reference				Reference			
Living with others who cannot provide sufficient care due to illness, or infirmity	68	12	176	2.06	0.89	4.79	0.09	2.38	0.97	5.82	0.06	2.64	1.07	6.51	0.04
Living with others who cannot provide sufficient care due to job	23	4	174	1.97	0.61	6.41	0.26	2.23	0.67	7.46	0.19	2.06	0.61	6.94	0.24
Living with another who is receiving long-term care insurance service	20	8	409	4.98	1.96	12.65	0.00	4.31	1.49	12.43	0.01	4.27	1.48	12.34	0.01
Living alone with frequent support from family and friends	15	4	265	2.66	0.82	8.56	0.10	2.52	0.69	9.17	0.16	2.20	0.61	7.93	0.23
Living alone without support from family or friends	1	2	2000	12.21	2.35	63.33	<0.01	20.04	2.38	168.54	<0.01	15.34	1.77	132.64	0.01

<sup>a</sup> Crude death rate per 1000 person-year.

<sup>b</sup> Model 1 included age, mobility and medical status.

<sup>c</sup> Model 2 included age, mobility, medical status, and use of long-term care insurance service.

<sup>d</sup> Level 5, ability of the elder to climb stairs without aid or assistive devices; level 4, cannot climb stairs without aid but can walk on flat surface without aid or assistive devices; level 3, cannot walk on a flat surface without aid, but can move around using assistive devices and perform transfer independently while seated; level 2, cannot either move around or transfer while seated using assistive device or aid from the others, but can sit up and maintain seated position; level 1, cannot either sit up or maintain seated position but can roll over on the bed without aid; and level 0, cannot roll over on a bed while lying without aid.

use of long-term care insurance service. These models included living arrangement, age, level of mobility, medical status, and use of long-term care insurance service as time-dependent variable. Subjects were further divided into two groups before analysis, those with relatively good mobility (mobility level 4 or 5) and less mobility (3 or less). The detailed levels of mobility status are still used for adjustment even in the good mobile and less mobile stratum. Data were analyzed using STATA statistical software, version 9 (Stata Corporation, College Station, Texas).

## Results

Table 1 shows characteristics of subjects by year of survey, and Table 2 shows baseline characteristics according to living arrangement group for men and women. Those living with others who were receiving long-term care insurance service were slightly older than the other groups and had a lower level of mobility. Subjects living with others who were receiving long-term care insurance service were more likely to receive long-term care insurance service themselves.

A significant difference in mortality by living arrangement was seen among elderly men (Table 3): mortality was higher among men living with others who cannot provide sufficient care due to illness, or

infirmity; those living with others receiving long-term care insurance care; and those living alone without support from family or friends than among men living with others able to provide care throughout the day (age-adjusted HR=1.52, 95%CI: 1.03–2.24; age-adjusted HR=1.87, 95%CI: 1.08–3.24; and age-adjusted HR=6.37, 95%CI: 2.60–15.59, respectively). These differences were heightened when analysis was limited to men with less mobility. In contrast, living arrangement was not associated with survival among elderly women (Table 4).

Among men with less mobility, mortality was higher among those living with others who cannot provide sufficient care due to illness or infirmity; those living with others receiving long-term care insurance care; and those living alone without support from family or friends than among men living with others able to provide care throughout the day (age-adjusted HR=2.06, 95%CI: 0.89–4.79; age-adjusted HR=4.98, 95%CI: 1.96–12.65; and age-adjusted HR=12.21, 95%CI: 2.35–63.33, respectively).

Of note, no association with mortality was seen for men living alone with frequent support from family and friends (age-adjusted HR=1.14, 95%CI: 0.61–2.11). In addition, when data for the two groups living alone were combined, age-adjusted HR of living alone was not statistically significant (age-adjusted HR=1.53, 95%CI: 0.91–2.59,  $p=0.108$ ; not shown in the table). When analysis was limited to men

**Table 4**  
Hazard ratios of living arrangement for mortality among women (Yukuhashi City, Japan, 2002–2007)

	Person year	Number of deaths	Death rate <sup>a</sup>	Age-adjusted			Model 1 <sup>b</sup>			Model 2 <sup>c</sup>					
				HR	95% CI	p	HR	95% CI	p	HR	95% CI	p			
Total	6810	156	23												
Living with others who provide care throughout the day	3553	77	22	Reference			Reference				Reference				
Living with others who cannot provide sufficient care due to illness, or infirmity	1040	22	21	1.25	0.78	2.03	0.35	1.14	0.70	1.85	0.60	1.19	0.73	1.94	0.48
Living with others who cannot provide sufficient care due to job	777	19	24	0.79	0.47	1.33	0.38	0.84	0.50	1.44	0.53	0.92	0.54	1.57	0.76
Living with another who is receiving long-term care insurance service	223	8	36	1.09	0.52	2.27	0.82	0.69	0.30	1.62	0.40	0.69	0.30	1.59	0.38
Living alone with frequent support from family and friends	1152	29	25	0.93	0.60	1.42	0.73	0.96	0.62	1.49	0.86	0.93	0.60	1.45	0.75
Living alone without support from family or friends	64	1	16	0.72	0.10	5.21	0.75	0.70	0.10	5.08	0.73	0.92	0.13	6.71	0.94
Mobility <sup>d</sup> level 4	6367	117	18												
Living with others who provide care throughout the day	3387	59	17	Reference				Reference				Reference			
Living with others who cannot provide sufficient care due to illness, or infirmity	972	14	14	1.18	0.65	2.14	0.59	1.22	0.67	2.23	0.52	1.26	0.69	2.30	0.46
Living with others who cannot provide sufficient care due to job	691	16	23	0.96	0.54	1.70	0.88	1.01	0.57	1.80	0.98	1.21	0.68	2.18	0.52
Living with another who is receiving long-term care insurance service	201	6	30	1.46	0.63	3.39	0.38	1.31	0.54	3.19	0.55	1.07	0.43	2.65	0.89
Living alone with frequent support from family and friends	1060	22	21	0.92	0.56	1.51	0.75	0.96	0.57	1.62	0.89	0.93	0.55	1.58	0.79
Living alone without support from family or friends	56	0	0	-	-	-	-	-	-	-	-	-	-	-	-
Mobility <sup>d</sup> level 3	442	39	88												
Living with others who provide care throughout the day	166	18	108	Reference				Reference				Reference			
Living with others who cannot provide sufficient care due to illness, or infirmity	68	8	118	1.70	0.71	4.11	0.24	1.64	0.67	4.00	0.28	1.64	0.67	4.01	0.28
Living with others who cannot provide sufficient care due to job	86	3	35	0.35	0.10	1.20	0.10	0.38	0.08	1.69	0.20	0.38	0.08	1.69	0.20
Living with another who is receiving long-term care insurance service	22	2	90	0.57	0.12	2.59	0.46	0.48	0.09	2.68	0.40	0.47	0.08	2.68	0.40
Living alone with frequent support from family and friends	92	7	76	0.94	0.38	2.34	0.90	1.11	0.44	2.80	0.83	1.11	0.44	2.81	0.83
Living alone without support from family or friends	8	1	123	1.59	0.21	12.27	0.66	2.53	0.24	27.12	0.44	2.58	0.24	28.29	0.44

<sup>a</sup> Crude death rate per 1000 person-year.

<sup>b</sup> Model 1 included age, mobility and medical status.

<sup>c</sup> Model 2 included age, mobility, medical status, and use of long-term care insurance service.

<sup>d</sup> Level 5, ability of the elder to climb stairs without aid or assistive devices; level 4, cannot climb stairs without aid but can walk on flat surface without aid or assistive devices; level 3, cannot walk on a flat surface without aid, but can move around using assistive devices and perform transfer independently while seated; level 2, cannot either move around or transfer while seated using assistive device or aid from the others, but can sit up and maintain seated position; level 1, cannot either sit up or maintain seated position but can roll over on the bed without aid; and level 0, cannot roll over on a bed while lying without aid.



with relatively good mobility, mortality was still higher for those living alone without support from family or friends (age-adjusted HR=4.16, 95%CI: 1.32–13.16).

Adjustment for mobility and medical status in model 1 did not substantially change the results, although statistical significance was attenuated for men living with others who cannot provide sufficient care due to illness or infirmity. Moreover, in model 2, further adjustment for use of long-term care insurance service, a significant difference in mortality by living arrangement was still seen among men with less mobility. Results for men living with others who cannot provide sufficient care due to illness or infirmity among men with less mobility became significant in model 2 (multivariable HR=2.64, 95% CI: 1.07–6.51).

## Discussion

In this study, we found that living arrangement according to the ability to receive informal care was significantly associated with survival in elderly men but not in women. Men living alone without support from family or friends had a greater risk of dying than those living with others able to provide care throughout the day, whereas men living alone but with frequent support from family and friends did not. In addition, among impaired men, those living with others who cannot provide sufficient care due to illness or infirmity and those living with others who are receiving long-term care insurance service showed a higher risk of mortality. To our knowledge, this study is the first to examine the association between living arrangement and mortality in terms of the ability to receive informal care.

Although the previous results suggested that living arrangement is not generally associated with mortality among men (Davis et al., 1997, Murata et al., 2005), these studies mostly focused on the difference between those living alone versus those living with someone else. In the present study, no increase in mortality was seen when the groups of men living alone were combined, which is consistent with previous findings (Davis et al., 1997, Davis et al., 1992, Magaziner et al., 1988, Murata et al., 2005), whereas a substantial difference was seen between those living alone with frequent support from family and friends versus those without support from family or friends. For women, findings from previous studies are inconsistent. A prospective study in a rural area of Japan found that women who lived alone had a lower mortality risk compared to those in multi-generation households (Murata et al., 2005). In contrast, a prospective study of 5085 elderly in the US found that living alone had no adverse effect on survival in women, whereas living with someone other than a spouse was associated with an increased mortality risk (Davis et al., 1997).

Given suggestions that health is a significant determinant of living arrangement (Magaziner et al., 1988, Sarwari et al., 1998, Soldo et al., 1984), it is interesting to consider whether living arrangement produces a change in health, or changes in health lead to a change in living arrangement. Elderly living alone rated themselves healthier than those living with others (Lawton et al., 1984, Magaziner et al., 1988). Persons who need help with activities of daily living are more likely to live with others than are those who can function independently (Soldo et al., 1984). In the present study, in men, the association of living arrangement with survival remained even after adjustment for medical status and mobility, which is a good proxy of function in the elderly. This in turn suggests that living arrangement, in terms of the availability of informal care, may have a causal association with the survival of elderly.

With regard to the mechanism of the effect of living arrangement on elderly health, it is important to distinguish between confounding and pathway, although these are not mutually exclusive. Confounding variables are ones which might either affect elder living arrangements, or might not independently distribute to groups of living arrangements, yet nevertheless also affect health. For example, socioeconomic

status, such as education and income, determine how elderly live, and also have an impact on health. One study reported that economic resources measured by income, change in income, and net worth dominate the decision-making process in transitions across living arrangements (Mutchler and Burr, 1991). On the other hand, pathway variables are variables which might be affected by living arrangements, and which themselves lead to a change in health. For example, smoking, alcohol drinking, dietary habit, mental health, and receipt of informal care may be determined by living arrangements and then lead to change in health.

The present study suggests two pathways that possibly contribute to differences in survival between groups of living arrangements. First, informal care is a major component of the effects of living arrangements on health among elderly. The present study shows a clear difference in survival between living arrangements according to the ability to receive informal care, while previous studies mostly focused on the difference between those living alone versus those living with someone else. This is also supported by the fact that the difference in survival was dramatically emphasized when the analyses were limited to those with less mobility. However, we did not ascertain the details of "informal care" or "support". "Informal care" and "support" have many dimensions and can be provided in different ways, such as financially, emotionally, physically, and materially. The benefit of financial support to the daily life of the aged is clear. Chatting with family and friends may also benefit mental well-being. Physical and material support, for example, includes help with housekeeping, preparation of daily meals, help with bathing, and accompaniment to outpatient clinics. In addition, adjustment for the use of long-term care insurance service did not substantially reduce differences in survival between living arrangement groups among men with less mobility. This suggests that the role of informal care is different from that of formal care, and that benefits from informal care cannot substitute for those from formal care service under the long-term care insurance. Further investigation of factors influencing survival among the aged is warranted.

The second pathway we suggest is social isolation or social network. Social isolation may play an important role in the mechanism by which living arrangement affects health, particularly for those living alone. This is because when the present analyses were limited to those who were relatively mobile, those living alone without support from family or friends still showed a higher risk of mortality, whereas those living alone with such support did not. This is consistent with previous findings of a likely association between social isolation and an increased risk of mortality. Although the mechanism of this association is unclear, psychosocial factors may play an important role (Berkman, 1987, Berkman and Syme, 1979, House et al., 1982, Kandler et al., 2007, Seeman et al., 1987). It has been suggested that living alone is a good proxy of social isolation or emotional loneliness, which are both in turn associated with increased morbidity and mortality (Kandler et al., 2007). Social network may also have an impact on cognitive function among elderly (Crooks et al., 2008, Ertel et al., 2008).

We speculate possible explanations for the lack of association between living arrangement and mortality in women. First, given gender-specific roles in the context of social situations in Japan, it is reasonable to assume that men are more vulnerable to the inability to conduct domestic affairs than women. Second, men are probably more susceptible to social isolation and stress, which are both related to living arrangement. A population-based cohort study conducted in the same setting as the present study reported that the risk of suicide was eight times higher among men living alone than those living with family members, whereas women showed no such difference (Fujino et al., 2005). A large nationwide cohort study conducted in Japan also reported a higher risk of mortality from cardiovascular disease, external causes and all causes associated with divorce and widowhood in men, but not in women (Ikeda et al., 2007). Third, living arrangement may influence changes in lifestyle-related behavior,

which may in turn be the mechanism of the association between living arrangement and health. However, these changes in women, even if they occurred, would have little impact on health because very few women engage in unfavorable lifestyle-related behaviors. In this area, smoking rate is approximately 50% in men versus 5% in women, and habitual alcohol consumption is 46% in men versus 4% in women (Fujino et al., 2001; Fujino et al., 2005; Pham et al., 2006; Pham et al., 2007).

Against the background of a declining birthrate, aging, and an increasing ratio of nuclear families, elder-to-elder care, in which one elderly person acts as the principal carer of another elderly person at home, has become a highly controversial public health issue in Japan. Our present results clearly show that when subjects are limited to those with impairments, men living with others who are receiving long-term care insurance service are frankly disadvantaged.

Several limitations of our study warrant mention. First, we did not obtain information on a number of important possible confounding and pathway variables, including smoking, drinking, physical exercise, nutritional intake, stress, medical diagnosis, economic status, education status, and formal care including institutionalized care. This limited adjustment weakens the conclusion. Second, the study did not include elderly who were institutionalized in a hospital or elderly home. Follow-up was also censored when they were institutionalized. Living arrangement may affect institutionalized care, but the study did not account for any effect of institutionalized care. Third, we did not identify the subject's marital status or distinguish whether they lived with a spouse or someone other than a spouse. Marital status and living arrangement may have separate effects on health, as might living with a spouse or with someone other than a spouse (Joung et al., 1994), albeit that no clear consensus has yet been obtained. Fourth, we did not account for the time lag in changes in living arrangement; rather, we assumed that the prior living arrangement had no health effect on the subsequent arrangement. Further, we measured living arrangement annually in repeat survey visits, and assumed that the risk of living arrangement changes were exerted simultaneously with the change in arrangement. Finally, the very few subjects in the group of living alone without support from family or friends should also be mentioned as limitation, though it yielded meaningful patterns.

In conclusion, we found that living arrangement as classified by the ability to receive informal care affects survival among elderly men. This effect was particularly pronounced when the men is impaired. In addition, men living alone without support from family or friends are at higher risk of dying even when their mobility is maintained, as they do when impaired. We also found that living alone does not adversely influence survival as long as the individual receives support from family and friends. These results may be useful in the formulation of elderly welfare policy. Development of the long-term care insurance system to provide informal care service which reflects the support provided by family and friends may be of overall benefit to the elderly.

#### Conflict of interest statement

The authors declare that there are no conflicts of interest.

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# 地域在住高齢者の転倒予防に対するCGAの活用

京都大学東南アジア研究所 松林公蔵

## Key words

地域在住高齢者, 転倒, 転倒リスクスコア, 転倒リスク, 運動教室

## 要約

地域在住高齢者の易転倒性を評価し, 易転倒性の関連リスク因子として, 高齢, ADLの障害, 抑うつが示唆され, 将来の転倒を予防するために, 厚生省研究班作成による「転倒リスクスコア」が有用であることを示した。また, 長期にわたる運動が, 将来の転倒に対して予防的効果を有することを, 地域在住高齢者に関する縦断的検討から明らかにした。さらに地域自治体などにおいて, 高齢者が運動を継続できるような運動のためのインフラ整備の重要性を提言した。

## はじめに

約700万年前に人類はチンパンジーとの共通の祖先から分かれ, やがて直立二足歩行を開始した。長い進化の過程のなかで, ヒトが二本足で立って直立姿勢を保ち, 二本足で歩行する能力を獲得したことは, ヒトが言語能力を獲得したこととならんで, ヒト化 (hominization) の重要なメルクマールである。直立歩行は, 手による道具の使用を通じて狩猟・採集活動を効率化し, ひいては脳の重量を増加させることにも寄与した。ヒトで直立二足歩行が可能となるためには, 進化の過程で, 骨盤骨の形態学的変化とともに姿勢反射という複雑な能力を獲得する必要があった。ヒトの個体発生の過程でも, 乳幼児が安定した姿勢反射能力を獲得するためには数年の成長年月を必要とする。そしてひとたび獲得したヒトの直立二足歩行の安定性は, 高齢期の老化の進行とともに衰退する。高齢者で問題となる転倒は, 加齢に伴う姿勢反射の障害がその主要な要因であり, 神経系の病的変化とともに最終的に起立・歩行障害 (Astasia Abasia) にいたることもある。高齢期に認められる病的な起立・歩行・姿勢の障害としては, 神経系の病変部位によって, 片麻痺, 対麻痺, 運動失調, パーキンソン病に伴う姿勢反射障害などさまざまなパターンを呈する。このような病的な起立・歩行障害を評価する方法としては神経学的診察が有効であるが, 生理的加齢に伴う姿勢反射の障害による易転倒性の評価は, 古典的な神経学的診察のみでは不十分な場合も少なくなく, 易転倒性をターゲットとした高齢者総合的機能評価 (Comprehensive Geriatric Assessment ; CGA) が重要となる。

## 地域在住高齢者における転倒の意義

高知県T町在住の65歳以上の高齢者1,261名(平均75.4歳)について、転倒の実態を調査してみると、転倒しない群862名に対して、何らかの易転倒者が399名(31.6%)存在した。この易転倒群と非転倒群において、基本的ADL 7項目の日常生活機能(歩行、階段昇降、摂食、排泄、入浴、更衣、整容)を3点(完全自立)から0点(完全介助)までの4段階で評価(0~21点)し、ならびに老研式活動能力指標13項目とその下部尺度である手段的活動能力(5項目)、知的能動性(4項目)、社会的役割(4項目)スコア示したのが表1である<sup>1)</sup>。易転倒群は非転倒群に比して有意に年齢が高く、また年齢を調整してもすべてのADL項目について有意に低いスコア値を示した。次に、両群において、15項目のGeriatric Depression Scale (GDS)によるうつスコアとGDS $\geq$ 10点以上の割合、さらにVisual Analogue Scale (VAS)を用いた主観的(QOL)5項目(主観的健康度、家族関係の満足度、友人関係の満足度、経済満足度、主観的幸福度)を比較したのが表2である<sup>2)</sup>。易転倒群は非転倒群に比して、うつ尺度が高く主観的QOLが低い。すなわち、地域在住高齢者において、易転倒性は、加齢ならびにADLの低下、うつがあること、主観的QOLが低いことと関連のある事実が明らかとなった。

表1 地域在住高齢者における易転倒者と非転倒者における日常生活機能の比較

	易転倒者 n=399 (31.6%)	非転倒者 n=862 (68.4%)	p値
年齢	76.9 $\pm$ 7.5	74.7 $\pm$ 6.9	<0.001
性比(男:%)	40.2	42.6	0.4
ADL			
基本的ADL(0~21)	19.1 $\pm$ 3.5	20.2 $\pm$ 2.5	<0.001*
老研式活動能力指標(0~13)	9.3 $\pm$ 3.8	10.7 $\pm$ 3.2	<0.001*
手段的活動能力(0~5)	4.0 $\pm$ 1.6	4.4 $\pm$ 1.3	<0.001*
知的能動性(0~4)	2.7 $\pm$ 1.3	3.2 $\pm$ 1.1	<0.001*
社会的役割(0~4)	2.8 $\pm$ 1.4	3.2 $\pm$ 1.2	<0.001*

\*年齢補正後p値

表2 地域在住高齢者における易転倒者と非転倒者における抑うつとQOL

	易転倒者	非転倒者	p値
年齢	76.9 $\pm$ 7.5	74.7 $\pm$ 6.9	<0.001
性比(男:%)	40.2	42.6	0.4
抑うつ			
GDS-15(0~15)	6.5 $\pm$ 4.1	4.3 $\pm$ 3.7	<0.001
GDS-15 $\geq$ 10の割合(%)	26.8	11.6	<0.001
QOL			
主観的健康度(0~100)	47.7 $\pm$ 21.8	56.7 $\pm$ 20.9	<0.001
家族関係の満足度(0~100)	72.3 $\pm$ 21.7	76.9 $\pm$ 20.3	<0.001
友人関係の満足度(0~100)	69.5 $\pm$ 23.1	74.3 $\pm$ 20.7	<0.001
経済満足度(0~100)	43.8 $\pm$ 24.9	51.2 $\pm$ 23.8	<0.001
主観的幸福度(0~100)	54.8 $\pm$ 22.0	62.0 $\pm$ 21.5	<0.001