

Original article

Travel Time to Hospital/clinic and Risk of Death or Nursing Care in Japanese Community-dwelling Elderly Adults: Y-HALE Cohort Study

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Abstract: In a cohort of Japanese aged adults, we estimated the hazard ratios (HRs) (95% confidence intervals) of travel time to the nearest hospital/clinic for mortality/nursing care and calculated coefficients of travel time for decline in the instrumental activities of daily living (IADL) score (range, 0–13). At baseline 2003 year, the mean (standard deviation) age, IADL score, and travel time to a hospital/clinic were 73.2 (5.6) years, 11.2 (2.8) points, and 18.0 (12.8)/13.1 (10.1) minutes, respectively, among the 283 participating women, and 76.2 (6.7) years, 11.2 (2.2) points, and 18.0 (13.3)/10.3 (7.1) minutes, respectively, among the 304 participating men. HRs for travel times of 20+ minutes and 10–19 minutes to a hospital as compared with 0–9 minutes were 1.50 (0.87–2.58) and 1.96 (1.23–3.13), respectively. The travel time to the nearest clinic was not significantly associated with the health outcomes. However, our results suggested that poor accessibility to a hospital increases the risk of mortality or nursing care. Optimizing the roll allotment of medical facilities and medical doctor specialties, networking of hospitals and clinics, and town planning may improve the health outcomes of aged adults.

Key Words: health services accessibility, mortality, nursing care, hospitals, ageing

INTRODUCTION

Regional disparities in socioeconomic status include municipal financial capacity, employment, income, and health services¹⁾. Because provided health services affect residents' health outcomes^{2,3)}, accessibility to hospitals and clinics is a major policy issue. A study in the United States (US) pointed out that poor accessibility

of health care services increases hospital admissions⁴⁾. Another US study revealed that frequent contact with hospital staff following discharge decreased the risk of rehospitalisation in patients with chronic diseases⁵⁾. In the United Kingdom (UK), risk of death from asthma increases with distance from a hospital⁶⁾, although there no association has been established between hospital accessibility and infant death risk⁷⁾.

A subset of individuals in Japan return to live in their hometown in middle age or after retirement. In these rural regions, public transportation to reach medical care can be poor owing to depopulation. Elderly people, who are at high risk of musculoskeletal disorders, tend to lose their ability to drive to receive medical care. In

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addition, a lack of available family members to accompany older individuals to health care facilities⁸⁾ and limits on the ability to judge their own health status⁹⁾ become barriers to tertiary prevention of their chronic diseases.

In Japan, all people are equally covered by health insurance. People can consult physicians at any type of hospital or clinic and department within the health insurance coverage, and all individuals pay the same fees for medical care at hospitals and clinics¹⁰⁾. Thus, health care availability and financial accessibility are considered to be nearly the same among all Japanese people; however, there may be great barriers of locational accessibility¹¹⁾. Whereas some studies have investigated the relationship between access to healthcare facilities and health outcomes, as described above, few have been conducted in high-income countries and among older populations. We explored the association of travel time to medical facilities with mortality or dependence on nursing care among a Japanese cohort of community-dwelling elderly people.

METHODS

Setting and participants

The setting of this study was Yamanashi Prefecture, Japan, which is adjacent to Tokyo Prefecture¹²⁾ and includes approximately 800,000 residents¹³⁾. The proportion of residents aged 65 years or more was 28.2% in 2016, in contrast to 27.0% nationwide in Japan. The main mode of transportation among residents of Yamanashi is a private car¹⁴⁾. In 2016, the mean number of owned car per individual was 0.91 in Yamanashi versus 0.78 nationwide; the mean number of cars owned in a single household was 2.3 in Yamanashi versus 1.5 nationwide.

In 2002, we randomly selected 1,800 residents of Yamanashi Prefecture, aged 65 years or more,

who had not received a long-term care insurance reimbursement from a municipality and thus were not registered as needing nursing care¹⁵⁾. These individuals were included in the 2002 cross-sectional survey of the Yamanashi Healthy Active Life Expectancy (Y-HALE) study, which was created to investigate the causes of longevity among residents of the prefecture. In 2003, we began a cohort study among 600 participants in this survey and collected their baseline characteristics including birthdate; age; residential environment; and comorbidities of diabetes and cardiovascular, cerebrovascular, chronic kidney, respiratory, gastrointestinal, musculoskeletal, gynaecological, and ophthalmological diseases¹⁶⁾. Because the need for nursing care was an outcome of the present study, participants who were already registered on 31 August 2004 as needing nursing care in the municipalities were excluded.

Exposure

For information on the exposure of interest, participants completed a questionnaire regarding their residential environment, including travel time needed to reach the nearest hospital or the nearest internal medicine clinic. These temporal accessibilities were measured in minutes. The means of transportation to medical facilities were categorised as walking, bicycling, and using a motor vehicle (car, bus, or motorbike). Within Yamanashi Prefecture, train transportation is rarely used among residents. For spatial accessibility, the distance to the nearest hospital/clinic was estimated as the length of time required to reach the facility multiplied by transportation speed. In the community-dwelling elderly population, speeds of walking, riding a bicycle, and traveling by car, bus, or motorbike to a medical institution were estimated as 2 km/h, 11.4 km/h, and 30 km/h, respectively^{17–20)}. The

Table 1. Questions for IADL rating in the Tokyo Metropolitan Institute of Gerontology Index of Competence

Questionnaires
Subscale of instrumental activities of daily living (IADL)
1 Can you use public transportation (bus or train) by yourself?
2 Are you able to shop for daily necessities?
3 Are you able to prepare meals by yourself?
4 Are you able to pay bills?
5 Can you handle your own banking?
Intellectual activeness
6 Are you able to fill out forms for your pension?
7 Do you read newspapers?
8 Do you read books or magazines?
9 Are you interested in news stories or programs dealing with health?
Social role
10 Do you visit the homes of friends?
11 Are you sometimes called on for advice?
12 Are you able to visit sick friends?
13 Do you sometimes initiate conversations with young people?

required time and estimated distance to the nearest medical facility was divided into tertiles.

Outcomes

In Japan, all people are required to be covered under public long-term care insurance from 40 years of age. From age 65 years or more, when the instrumental activities of daily living (IADL) of elderly persons decrease, municipalities provide the persons with in-kind medical services²¹⁾. Under Japanese law, elderly people with more severe disabilities can receive nursing care services through a request made by either themselves or a family member. These services include visits by a home care worker or nurse, day care, short stay, and rental of welfare equipment. In this study, we surveyed death events among participants using local newspaper announcements and postal mailings from the family of deceased people. Along with death events, we collected information on the outcome of registration for nursing care; every October from 2004 to 2014,

we mailed questionnaires asking if participants had registered as needing nursing care, and the type of the care by the long-term insurance, date of registration, and severity of disability according to IADL score. The IADL score was measured in the Tokyo Metropolitan Institute of Gerontology Index of Competence (TMIG-IC)²²⁾. The TMIG-IC, constructed to measure independent living skills among Japanese elderly people and corresponding to Lawton's IADL score²³⁾, has been previously validated^{22,24,25)}. This IADL score of the TMIG-IC includes 13 questions; a response of "yes" to each question equals 1 point, with total scores ranging from 0 to 13 points and higher scores indicating higher competence of elderly people. Table 1 presents the details of this rating. If the participant or their family did not reply to the mailing, we repeatedly tried to contact them by mail or by phone.

Statistical analysis

The data are presented as mean (standard de-

viation [SD]) of age, income, and travel time to the nearest hospital/clinic, as well as the proportion of participants with a history of hospitalisation for any disease; those who were living alone; and current, former, or never smokers and alcohol drinkers.

We considered death or the need for nursing care as the worst outcome for healthy life expectancy among our elderly participants and set these as the primary outcomes. We performed time-to-event analysis using Cox proportional models to present hazard ratios (HRs) and 95% confidence intervals (95% CIs) of the association between travel time to medical facilities and the outcome, with adjustment for covariates. Covariates considered to be associated with the outcome of elderly people were as follows: sex^{26,27}, age²⁸, illness^{29–31}, medication³², histories of smoking and drinking³¹, educational background³³, income³³, and residential situation²⁷. For sensitivity analysis in this investigation, we calculated multivariate-adjusted HRs, stratified by sex.

Of course, we could not measure declining IADL among deceased participants in the cohort. However, for other sensitivity analyses, we performed multiple linear regression on the change in IADL score from 2004 to 2014 in relation to travel time and spatial distance. In this analysis, we determined coefficients of the difference in the categories or one incremental value in the explanatory variables at baseline. We also stratified the results of this multiple linear regression by sex. All analyses were performed using SAS version 9.4 (SAS Institute Inc., Cary, NC, US). All reported *p* values were two-sided, with values of <0.05 considered to indicate statistical significance.

RESULTS

Characteristics of participants

Table 2 shows the baseline characteristics of participants. In 2003, the means of age, IADL score, and income and proportion of current smokers and alcohol drinkers were greater among men than women, whereas the proportion of never smokers was greater among women than men. Mean travel time to the nearest hospital or clinic was nearly the same between women and men.

Hazard ratios

Through 2014, a total of 167 elderly participants died and 157 were registered in their municipalities as needing nursing care (Figure 1). Table 3 shows the crude and adjusted HRs of explanatory variables for the primary outcome. The adjusted HRs indicated that older age at baseline and travel time to a hospital of 10–19 minutes were significantly associated with increased risk of the outcome. Despite no statistical significance, travel time to the nearest hospital of 20 minutes or more was positively associated with increased risk of this outcome. Travel time to the nearest clinic was not associated with this risk.

Table 4 shows the results of sex-specific multivariate analyses using a Cox proportional model. For both sexes, older baseline age presented significantly increased risk of the primary outcome. Particularly for men, travel time to the nearest hospital of 10–19 minutes was significant; that of 20 minutes or more was considered to be non-significantly associated with increased risk. In women, living alone was significantly associated with increased risk of the outcomes.

Results of linear regression for change in IADL

We analysed data from a total of 259 residents

Table 2. Baseline characteristics of elderly participants in the Y-HALE cohort of Japan

Mean (standard deviation) or number (%)	Women (n=283)	Men (n=304)
Age, years	73.2 (5.6)	76.2 (6.7)
Instrumental activities of daily living	11.2 (2.8)	11.2 (2.2)
Income, 100,000 JPY	1.09 (1.21)	2.85 (4.61)
Educational background, less than high school	132 (52)	164 (61)
Travel time to hospital, minutes	18.0 (12.8)	18.0 (13.3)
Travel time to clinic, minutes	13.1 (10.1)	10.3 (7.1)
Distance to hospital, kilometres	7.7 (6.8)	8.3 (6.0)
Distance to clinic, kilometres	4.2 (5.0)	4.6 (3.8)
History of chronic disease	197 (70)	231 (76)
Medication	204 (70)	232 (75)
Smoking		
Current smoker	6 (2)	67 (22)
Former smoker	9 (3)	159 (52)
Never smoker	267 (95)	78 (26)
Drinking alcohol		
4–7 times/week	22 (8)	137 (45)
0–3 times/week	261 (92)	167 (55)
Family		
Living alone	38 (13)	16 (5)
Living only with spouse	81 (29)	130 (43)
Other	164 (58)	158 (52)

Abbreviation: Y-HALE, Yamanashi Healthy Active Life Expectancy.

Baseline in 2003

A total of 587 residents aged 65 years or more were participating in the Yamanashi Healthy Active Life Expectancy Cohort.



Outcome for mortality or nursing support

Through 2014, 167 participants died and 157 were registered in their municipality as needing nursing support, based on the law of public long-term care insurance.

Outcome for IADL

In 2014, 328 participants were excluded for missing data of instrumental activities of daily living (IADL). Data of 127 women and 132 men were analysed in the multiple regression.

Figure 1. Participant analysis for outcomes of mortality or need for nursing care and instrumental activities of daily living

Table 3. Hazard ratios for death or nursing care among 587 Japanese people aged ≤ 65 years

Explanatory variable	Crude HR (95% CI)	p value	Multivariable HR (95% CI)	p value
Male sex	1.29 (0.92, 1.83)	0.14	1.25 (0.75, 2.11)	0.40
Age, years	1.11 (1.08, 1.14)	<0.0001	1.12 (1.09, 1.16)	<0.0001
Illness	1.30 (0.85, 1.98)	0.23	0.90 (0.57, 1.41)	0.64
Medication	1.36 (0.92, 2.03)	0.13	0.92 (0.58, 1.47)	0.73
Time to hospital 20+ min	1.38 (0.87, 2.19)	0.17	1.50 (0.87, 2.58)	0.15
Time to hospital 10–19 min	1.51 (1.002, 2.26)	0.049	1.96 (1.23, 3.13)	0.005
Time to hospital 0–9 min	Ref	—	Ref	—
Time to clinic 10+ min	1.27 (0.83, 1.96)	0.28	0.74 (0.44, 1.26)	0.27
Time to clinic 5–9 min	1.29 (0.85, 1.95)	0.23	1.07 (0.67, 1.70)	0.77
Time to clinic 0–4 min	Ref	—	Ref	—
Current smoker	1.17 (0.69, 2.00)	0.56	1.07 (0.55, 2.09)	0.84
Former smoker	1.36 (0.94, 1.97)	0.10	1.18 (0.70, 1.99)	0.54
Never smoker	Ref	—	Ref	—
Drinks alcohol 4–7 times/wk	0.99 (0.68, 1.45)	0.98	0.80 (0.50, 1.27)	0.34
Education, below high school	2.12 (1.45, 3.11)	0.0001	1.25 (0.78, 2.01)	0.35
Income, 100,000 JPY	0.99 (0.94, 1.04)	0.60	1.004 (0.96, 1.05)	0.88
Living alone	1.98 (1.08, 3.62)	0.03	1.49 (0.74, 2.99)	0.27
Living only with spouse	Ref	—	Ref	—
Other	1.46 (1.01, 32.12)	0.05	1.13 (0.73, 1.76)	0.58

Abbreviations: HR, hazard ratio; CI, confidence interval; Ref, reference category.

with IADL scores who were alive in 2014 (Figure 1). Table 5 shows the results of regression for the change in IADL score from 2004 to 2014 in relation to travel time or distance to a hospital and clinic, adjusting for confounding factors. Only age was a significant predictor of decreasing IADL scores: each one-year increment from the age at baseline was significantly associated with a -0.42 (95% CI: -0.54 , -0.30 ; $p < 0.0001$) change in IADL score. Relative to less than 10 minutes, 20 minutes or more and 10–19 minutes needed to reach a hospital was non-significantly associated with changes in IADL score of -1.03 (95% CI: -2.56 , 0.49 ; $p = 0.18$) and -0.04 (95% CI: -1.34 , 1.26 ; $p = 0.96$), respectively. Travel times to a clinic of 10 minutes or more and 5–9 minutes, relative to 4 minutes or less, were non-significantly associated with changes in IADL score

of $+0.06$ (95% CI: -1.42 , 1.55 ; $p = 0.93$) and -0.20 (95% CI: -1.46 , 1.06 ; $p = 0.75$), respectively. In the sensitivity analysis of distance, relative to less than 5 km, living 10 km or greater and 5–9 km from a hospital was non-significantly associated with changes of -1.15 (95% CI: -2.77 , 0.47 ; $p = 0.16$) and -0.68 (95% CI: -2.03 , 0.68 ; $p = 0.32$) in IADL scores, respectively. Similarly, relative to less than 2.5 km, living 5 km or greater and 2.5–4.9 km from a clinic was non-significantly associated with changes of -0.19 (95% CI: -1.83 , 1.45 ; $p = 0.82$) and -0.31 (95% CI: -1.63 , 1.01 ; $p = 0.65$) in IADL scores, respectively.

Table 6 shows results of the association between travel time to a hospital and clinic and changes in IADL for each sex. A pattern of significantly decreasing IADL as a function of age was observed in both sexes. Travel time 20 min-

Table 4. Hazard ratios for mortality or nursing care among Japanese women and men aged ≤65 years

Explanatory variable	Women (n=283)		Men (n=304)	
	HR (95% CI)	p value	HR (95% CI)	p value
Age, years	1.14 (1.09, 1.20)	<0.0001	1.13 (1.08, 1.17)	<0.0001
History of hospitalisation	0.90 (0.41, 1.95)	0.79	0.87 (0.47, 1.60)	0.65
Medication	0.77 (0.37, 1.60)	0.48	0.91 (0.48, 1.71)	0.77
Time to medical institutions				
Time to hospital 20+ min	0.91 (0.37, 2.19)	0.82	1.75 (0.84, 3.63)	0.14
Time to hospital 10–19 min	1.32 (0.62, 2.81)	0.46	2.87 (1.52, 5.41)	0.001
Time to hospital 0–9 min	Ref	—	Ref	—
Time to clinic 10+ min	0.73 (0.30, 1.78)	0.49	0.81 (0.40, 1.67)	0.57
Time to clinic 5–9 min	0.80 (0.36, 1.78)	0.59	1.21 (0.67, 2.19)	0.53
Time to clinic 0–4 min	Ref	—	Ref	—
Smoking habits				
Current smoker	0.30 (0.03, 2.68)	0.28	1.09 (0.51, 2.35)	0.82
Former smoker	2.51 (0.82, 7.70)	0.11	0.997 (0.54, 1.84)	0.99
Never smoker	Ref	—	Ref	—
Alcohol consumption				
4–7 times/wk	0.37 (0.10, 1.33)	0.13	1.04 (0.61, 1.79)	0.88
0–3 times/wk	Ref	—	Ref	—
Education below high school	1.004 (0.49, 2.05)	0.99	1.59 (0.83, 3.06)	0.16
Income, 100,000 JPY	0.76 (0.47, 1.22)	0.26	1.01 (0.97, 1.06)	0.38
Family				
Living alone	2.78 (1.02, 7.53)	0.045	0.67 (0.19, 2.41)	0.38
Living only with spouse	Ref	—	Ref	—
Other	1.13 (0.52, 2.50)	0.76	1.24 (0.72, 2.15)	0.44

Note: Results of multivariable Cox proportional regression.

Abbreviations: HR, hazard ratio; CI, confidence interval; Ref, reference category.

utes or greater to a hospital was non-significantly associated with a -0.90 (95% CI: $-3.24, 1.44$; $p=0.44$) change in women and a -1.56 (95% CI: $-3.67, 0.55$; $p=0.14$) change in IADL score in men. For accessibility to a clinic, travel time 10 minutes or greater was non-significantly associated with a $+0.54$ (95% CI: $-1.56, 2.63$; $p=0.61$) change in women and a -0.62 (95% CI: $-3.01, 1.78$; $p=0.61$) change in IADL score for men.

DISCUSSION

Statement of the principal findings

In this study, the data suggested that living 10 minutes or greater from the nearest hospital, compared with 9 minutes or less, may be associated with greater risk of death or need for nursing care (table 3). This risk was more pronounced in elderly men (table 4).

Results in the context of previous reports

A 2006 US study reported that long distance from people's residences to the closest hospital

Table 5. Beta coefficients (95% CI) of crude and multivariable regression, change in IADL over 10 years

Explanatory variable	Crude beta (95% CI)	p value	Multivariable beta (95% CI), time to hospital/clinic	p value	Multivariable beta (95% CI), distance to hospital/clinic	p value
Male sex	1.18 (0.34, 2.03)	0.006	0.05 (−1.57, 1.67)	0.95	−0.20 (−1.84, 1.45)	0.81
Age, years	−0.36 (−0.43, −0.29)	<0.0001	−0.42 (−0.54, −0.30)	<0.0001	−0.43 (−0.56, −0.30)	<0.0001
History of hospitalisation	0.16 (−0.78, 1.10)	0.74	0.79 (−0.42, 1.99)	0.20	0.55 (−0.71, 1.81)	0.39
Medication	−0.62 (−1.52, 0.28)	0.18	−0.03 (−1.20, 1.13)	0.96	−0.003 (−1.22, 1.22)	0.996
Time to medical institutions						
Time to hospital 20+ min	−0.97 (−2.34, 0.39)	0.16	−1.03 (−2.56, 0.49)	0.18		
Time to hospital 10–19 min	−1.08 (−2.17, 0.004)	0.051	−0.04 (−1.34, 1.26)	0.96		
Time to hospital 0–9 min	Ref	—	Ref	—		
Time to clinic 10+ min	−1.18 (−2.44, 0.08)	0.07	0.06 (−1.42, 1.55)	0.93		
Time to clinic 5–9 min	0.06 (−1.19, 1.30)	0.93	−0.20 (−1.46, 1.06)	0.75		
Time to clinic 0–4 min	Ref	—	Ref	—		
Distance to medical institutions						
Living 10+ km from hospital	−0.80 (−2.21, 0.60)	0.26			−1.15 (−2.77, 0.47)	0.16
Living 5–9 km from hospital	−1.17 (−2.31, −0.04)	0.04			−0.68 (−2.03, 0.68)	0.32
Living 0–4 km from hospital	Ref	—			Ref	—
Living 5+ km from clinic	−0.86 (−2.20, 0.49)	0.21			−0.19 (−1.83, 1.45)	0.82
Living 2.5–4.9 km from clinic	0.79 (−0.48, 2.05)	0.22			−0.31 (−1.63, 1.01)	0.65
Living 0–2.4 km from clinic	Ref	—			Ref	—
Smoking habits						
Current smoker	0.74 (−0.62, 2.10)	0.29	0.20 (−1.74, 2.14)	0.84	0.39 (−1.56, 2.34)	0.98
Former smoker	1.18 (0.22, 2.13)	0.02	1.14 (−0.38, 2.66)	0.14	1.08 (−0.49, 2.64)	0.18
Never smoker	Ref	—	Ref	—	Ref	—
Alcohol consumption						
4–7 times/week	0.81 (−0.15, 1.76)	0.10	1.25 (−0.03, 2.54)	0.06	1.27 (−0.03, 2.58)	0.06
0–3 times/week	Ref	—	Ref	—	Ref	—
Education less than high school	−0.89 (−1.80, 0.02)	0.06	0.50 (−0.64, 1.63)	0.39	0.54 (−0.63, 1.71)	0.37
Income, 100,000 JPY	0.11 (−0.02, 0.23)	0.09	0.03 (−0.10, 0.17)	0.63	0.04 (−0.10, 0.18)	0.61
Family						
Living alone	−3.63 (−5.33, −1.94)	<0.0001	−2.06 (−4.59, 0.47)	0.11	−2.10 (−4.68, 0.47)	0.11
Living only with spouse	Ref	—	Ref	—	Ref	—
Other	−0.49 (−1.35, 0.38)	0.27	−0.17 (−1.29, 0.95)	0.76	−0.26 (−1.45, 0.93)	0.66

Abbreviations: IADL, instrumental activities of daily living; CI, confidence intervals; Ref, reference category.

was associated with increased mortality owing to a heart attack and unintentional injuries³⁴). In the US, where medical insurance is not equally available to residents, long distance to the hospital also worsens the prognosis of patients in the emergency department. Another US study sug-

gested that long distance from a radiotherapy facility prevented patients with breast cancer from receiving radiotherapy in place of surgical mastectomy³⁵). That study indicated that the selection of medical care for a patient with a disease or illness would depend upon the medical

Table 6. Change in IADL over 10 years in relation to temporal accessibility to hospital/clinic in elderly Japanese women and men
Coefficients (95% CI) of the results of multivariable regression

Explanatory variable	Women (n=127)		Men (n=132)	
	Multivariable beta	p value	Multivariable beta	p value
Age, years	-0.52 (-0.68, -0.35)	<0.0001	-0.37 (-0.55, -0.18)	0.0002
Illness	1.02 (-0.77, 2.81)	0.26	0.95 (-0.86, 2.75)	0.30
Medication	0.34 (-1.31, 1.98)	0.68	-0.18 (-1.98, 1.62)	0.84
Time to hospital 20+ min	-0.90 (-3.24, 1.44)	0.44	-1.56 (-3.67, 0.55)	0.14
Time to hospital 10–19 min	0.11 (-1.75, 1.97)	0.91	-0.46 (-2.44, 1.52)	0.64
Time to hospital 0–9 min	Ref	—	Ref	—
Time to clinic 10+ min	0.54 (-1.56, 2.63)	0.61	-0.62 (-3.01, 1.78)	0.61
Time to clinic 5–9 min	1.02 (-0.87, 2.91)	0.28	-0.81 (-2.62, 1.00)	0.37
Time to clinic 0–4 min	Ref	—	Ref	—
Current smoker	-4.20 (-10.70, 2.30)	0.20	1.50 (-0.80, 3.79)	0.20
Former smoker	-4.02 (-7.36, -0.68)	0.02	2.53 (0.62, 4.44)	0.01
Never smoker	Ref	—	Ref	—
Drinks alcohol 4–7 times/wk	1.93 (-1.06, 4.93)	0.20	1.59 (-0.01, 3.19)	0.05
Drinks alcohol 0–3 times/wk	Ref	—	Ref	—
Education below high school	0.02 (-1.62, 1.67)	0.98	0.29 (-1.49, 2.08)	0.74
Income, 100,000 JPY	0.20 (-0.27, 0.68)	0.39	0.003 (-0.15, 0.16)	0.97
Living alone	-0.85 (-3.54, 1.84)	0.53	—	—
Living only with spouse	Ref	—	Ref	—
Other	0.66 (-1.11, 2.44)	0.46	-0.48 (-2.05, 1.10)	0.55

Note: The coefficient of 'living alone' could not be analysed for male data.

Abbreviation: IADL, instrumental activities of daily living; CI, confidence interval; Ref, reference category.

specialities and services available at the nearest hospital or clinic. Extrapolating this result to the Japanese situation, variation of physicians' specialities in the closest hospital may sway the choice of treatment and prognosis of patients. We consider that further research is needed to evaluate the importance of clinical specialists upon health outcomes of Japanese patients.

Sensitivity analysis

In sensitivity analysis of the association between distance and IADL change (table 6), we estimated the travel speeds among participants as 2 km/h for walking, 11.4 km/h for bicycling, and 30 km/h for driving in a car. The walking

speed of adults in Japan is commonly estimated at 4 km/h. Our estimate of 2 km/h for elderly people who walk unassisted or use a walker was based on a reference from the National Police Agency of Japan¹⁷⁾. Another previous study estimated the speed of bicycling among Japanese elderly people as 11.4 km/h^{18,19)}. In Japan, the car driving speed is estimated at 20–30 km/h in residential districts and 40 km/h in the suburbs. A website that drivers commonly access to estimate arrival times uses an average driving speed of 30 km/h for Yamanashi Prefecture²⁰⁾. Therefore, we used 30 km/h as the driving speed for estimating distances when elderly people use a car to reach a health care facility. Although the

results did not achieve statistical significance, the sensitivity analysis suggested that the distance to a hospital or clinic (and therefore travel time to reach such a facility) may also be associated with declines in IADL.

Possible explanations

A Canadian study reported that the walkability of a neighbourhood is associated with decreased incidence of obesity and diabetes³⁶⁾. In rural districts of Japan, people usually travel short distances in their own cars¹⁴⁾. This phenomenon is more prominent in sparsely inhabited areas³⁷⁾. The studied prefecture includes underpopulated districts. Residents in mountainous areas have poor access to medical care, public services, and supermarkets. The fact that they frequently drive a car rather than walk would result in greater mortality and decline in IADL owing to a higher prevalence of metabolic and musculoskeletal diseases.

A study in the Netherlands reported that patients with acute myocardial infarction who have good temporal accessibility to health care facilities had better prognosis³⁸⁾. Therefore, temporal accessibility to acute care facilities may influence mortality among elderly people through delays in the treatment of time-critical serious diseases. In a US study, discharged patients with congestive heart failure (a chronic disease) who had better access to primary care had lower probability of hospital readmission⁵⁾. Mortality among elderly people with chronic diseases may also be affected by insufficient opportunities to consult with physicians. While hospitals are relatively abundant in densely populated urban areas, in our study districts, elderly people require average 18 minutes to reach a hospital, even with a car.

For fever or control of noncommunicable diseases, people visit a primary care clinic; for acute

or severe symptoms or disorders such as a loss of consciousness that require further or extensive examination, they would select a hospital. Although family doctors in clinics can assess the prognosis and activities of daily living (ADLs) of patients with chronic diseases like hypertension, diabetes, and dyslipidaemia, the speciality of family medicine has not yet been defined in Japan³⁹⁾. Moreover, accreditation of physicians' specialities and subspecialities are currently underway in Japan⁴⁰⁾. Specialists are sparsely distributed throughout rural districts⁴¹⁾. For these reasons, poor accessibility to specialists may have affected IADL scores among elderly people who are vulnerable to serious diseases, and the accessibility may have affected their mortality or need for nursing care.

Implications for policymakers

Because the present results suggest that access time of 10 minutes or greater to a hospital worsens the mortality risk or quality of daily living among elderly residents of rural districts, medical policy-makers should consider how best to control acute and chronic diseases in these populations. Amongst G7 countries, Japan has the lowest number of practicing doctors per population, the largest number of hospital beds per population, and the lowest expenditure on health in GDP⁴¹⁾. In a country like Japan with fewer human and economic resources than medical expenses, future policies may need to include selection and concentration of the resources, utilisation of information and communication technology, or a compact city vision. Health care administrators must take next steps toward improving the delivery of medical care to patients with both acute and chronic diseases in rural districts.

Our results may suggest one solution to this mixed problem. Our results pointed out that

clinics were located relatively close to participants' residence (table 2), and travel time to the nearest clinic was not associated with mortality or need for nursing care (tables 3 and 4). This means that a primary care doctor (i.e., family doctor) living very close to the residence of elderly people with chronic diseases could provide medical care more intensively. In rural districts, having a primary care doctor in a clinic can improve patients' medication adherence and self-management, and the primary care doctor could respond in the case of illness exacerbation. We suggest that family medicine as general practice closest to patients should be regarded as a speciality, and that functional differentiation and referral networks between clinics and hospitals should be established⁴². Experts point out that Japan has adopted a policy of tight control of health care costs and a laissez-faire approach to service delivery⁴⁰. It may be time for the Japanese government and municipal authorities to organise how patients can more easily consult with physicians, to better control disease and illness.

Recently in Japan, people in suburbs and rural areas have been more dependent on their own cars than public transportation for their daily activities²³. A subset of regional routes of local trains and buses has been discontinued owing to a lack of business¹⁴. Subsequently, many municipal administrators have developed and provided economic support for community-based and on-demand bus systems and shared taxis for towns and villages where residents can no longer utilise public transportation²⁴. However, the transportation operators in rural districts have difficulty running those systems owing to annual deficits, and some of the projects have failed⁴³. The problem of a lack of transportation to medical and public services has not been solved. Additionally, in Japan with a high rate of

ageing population⁴⁴, the number of older people without a driving license is increasing, while the number of bus and taxi drivers is decreasing²⁴. Indeed, elderly people residing in "transit deserts" have more difficulty buying food and receiving medical care and public services^{25–27}. In such situations, people may not need to live in such a dispersed manner; a plan for compact cities may solve this inequality in access to medical services⁴⁵.

Another possible solution is to have a public health nurse visit elderly people in their homes to check for disease-related symptoms. These nurses could recommend physician consultations and prevent the decline of ADLs in regions of the countryside where elderly people have poor access to medical facilities; however, a systematic review in 2000 was against this idea⁴⁶. Nevertheless, an Australian study revealed that compared with hospital-based service alone, effectively planned outreach of medical specialists can compensate for reduced access to care in medically isolated districts⁴⁷. Administrators could therefore consider options for systems of alternative delivery of medical-care professionals for people living in isolation, far from hospitals and clinics.

Strengths and weaknesses in relation to other studies

This study has several strengths. First, semi-random sampling was used during recruitment: 1,800 elderly persons were sampled randomly from the prefecture; those who agreed to participate were enrolled. Although the sample in this study was not selected strictly at random, the sample was well distributed across the prefecture, from the suburbs to rural areas. Second, important factors known to be associated with mortality and decline in ADLs among elderly people were included in the analyses, namely, medication, smoking habits, alcohol use, and

social isolation⁴⁸). Additionally, no published studies exist on the relationship between hospital/clinic accessibility and ADL or IADL. Our data included a longitudinal change in IADL; we were able to link declining IADLs in elderly Japanese people with several risk and protective factors.

This study also has several limitations. First, when dividing the study region into suburban and rural areas, we found that small hospitals in rural areas occasionally function more like clinics for local residents; i.e., these hospitals provide both primary care, specialised outpatient, and general and specialised inpatient departments. Second, because the measured travel time to access hospitals and clinics were 10–18 minutes on average (table 2), it may have been difficult to discern associations of accessibility of hospitals and clinics with mortality. Third, the results may not be sufficiently adjusted for risk factors associated with mortality in elderly people. Previous studies refer to variables of nutritional intake⁴⁹ and physical activity^{50,51}. Assessment of impairments in hearing and vision may also be needed when evaluating mortality⁵² and ADLs⁴⁸. Fourth, the elderly people in the study region might not represent the entire elderly population of Japan. Although this problem is inherent in observational studies, conducting the study in a single prefecture admittedly limits extrapolation to the general Japanese population. Fifth, the sample sizes in the sex-stratified analyses may be relatively small, which may have masked the risk of longer travel time to the nearest hospital.

Conclusions

Our data suggest that poor accessibility to a hospital, with travel time of 10 minutes or greater, is associated with high HR of mortality or need for nursing care among elderly people;

this risk is more pronounced in men. This may be attributable to delays in primary treatment and follow-up care for acute and chronic diseases. Whereas geographical redistribution of hospitals and specialised physicians may be difficult, clarification of medical facility functions and specialities, networking of hospitals and clinics, and better town planning would improve the health outcomes of elderly people residing in rural districts.

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CONFLICT OF INTEREST

The authors declare that they have no competing interests.

Abbreviations

ADL: activities of daily living; IADL: instru-

mental activities of daily living; TMIG-IC: Tokyo Metropolitan Institute of Gerontology Index of Competence; Y-HALE: Yamanashi Healthy Active Life Expectancy; US: United States; UK: United Kingdom; SD: standard deviation; HR: hazard ratio; 95% CI: 95% confidence interval; AMI: acute myocardial infarction.

Ethics approval and consent to participate

The ethics committee of the School of Medicine, University of Yamanashi approved this study (approval number: 17152), in accordance with the ethical guidelines and regulations of the Declaration of Helsinki. Participants provided written informed consent; they were informed that they could drop out of the study with a written request or phone call if they decided not to participate in the study. In addition, they could comment on the study results and could convey their wishes for the study by completing and mailing a questionnaire to the study group.

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Authors' contributions

HY and ZY conceived the study, HY contributed to the study design, and ZY and HY interpreted the data. HY analysed the data. XH and HY wrote the first draft of the manuscript. HY contributed to revision of the manuscript. ZY was responsible for data integrity. ZY and HY obtained funding. All of the authors agreed with the results and conclusion of the study and approved the final version of the manuscript.

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