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REGULAR ARTICLE

Rural–urban differences in the prevalence of cognitive impairment in independent community-dwelling elderly residents of Ojiya city, Niigata Prefecture, Japan

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Abstract
Background This study aimed to examine rural–urban differences in the prevalence of cognitive impairment in Japan.
Methods We targeted 592 residents aged 65 years and older who did not use long-term care insurance services in one rural and two urban areas in Ojiya City, Japan. Of these, 537 (90.7 %) participated in the study. The revised Hasegawa's dementia scale (HDS-R) was used to assess cognitive function, and cognitive impairment was defined as a HDS-R score ≤20. Lifestyle information was obtained through interviews. The prevalence of cognitive impairment was compared according to the levels of predictor variables by odds ratios (ORs) calculated by a logistic regression analysis.
Results Mean age of participants was 75.7 years (SD 7.0). The prevalence of cognitive impairment was 20/239 (8.4 %) in the rural area and 6/298 (2.0 %) in the urban areas, for a total of 26/537 (4.8 %) overall. Men tended to have a higher prevalence of cognitive impairment ($P = 0.0628$), and age was associated with cognitive impairment (P for trend <0.0001). The rural area had a significantly higher prevalence of cognitive impairment (age- and sex-adjusted OR = 4.04, 95 % CI: 1.54–10.62) than urban areas. This difference was significant after adjusting for other lifestyle factors.
Conclusions The prevalence of cognitive impairment was higher in the rural area relative to urban areas in Ojiya city. This regional difference suggests the existence of potentially modifiable factors other than lifestyle in relation to cognitive impairment.

Keywords Cross-sectional studies · Mild cognitive impairment · Prevalence · Rural health · Urban health

Introduction

Dementia is becoming a global public health concern. An estimated 36 million people globally had dementia in 2010, and the number is expected to almost double every 20 years [1]. Japan, with a rapidly aging population, is no exception. There were 2.8 million individuals with dementia in 2010, and this is expected to increase to 4.7 million by 2025 [2]. These values would equate to prevalences (in people aged ≥65 years) of 9.5 % in 2010 and 12.8 % in 2025. Given this dire situation, prevention of dementia at any stage would be beneficial.

Cognitive impairment, including mild cognitive impairment (MCI: the early or intermediate stages of dementia) and dementia, poses a public health burden in society, and those with cognitive impairment are prone to age-related frailty [3], which can increase care costs [4]. Therefore, epidemiological profiles of cognitive impairment in communities warrant researching.

The prevalence of cognitive impairment increases steeply with age in elderly populations. There is also a gender difference in the prevalence of cognitive impairment [5]. In

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addition to demographic factors, environmental factors may also be involved in cognitive impairment or decline [6, 7]. Among them, rural–urban differences in the prevalence of cognitive impairment represent one issue that has attracted much interest. These differences imply potentially modifiable factors, which are interventional targets for dementia prevention. Geographical differences in dementia have been reported [8], and a number of socio-environmental factors, including rural–urban differences, may contribute to such differences. In this context, well-designed studies are needed to assess the contribution of rural–urban differences to cognitive impairment.

There is little evidence concerning this issue in Japan. To address this, we designed a cross-sectional study to investigate the prevalence of cognitive impairment in rural and urban communities within a city by conducting an exhaustive survey. This study aimed to determine rural–urban differences in the prevalence of cognitive impairment in one Japanese community.

Participants and methods

Participants

Ojiya city, with a population of about 38,000, is located in the middle of Niigata Prefecture, Japan. Working populations of the primary, secondary, and tertiary industries in Ojiya in 2010 were 8, 39, and 53 %, respectively [9]. The city government conducted thorough interview investigations in three model areas they had set up, namely, Heisei-cho (an urban area), Matto (a rural, farming area), and central Katakai (an urban area). Regarding Katakai, four business or residential subareas, including Ninocho, Chabatake, Omotesannocho, and Inaba, were investigated. They targeted all residents aged 65 years and older who did not use long-term care insurance. Profiles of the three study areas are shown in Table 1. There were 166 eligible individuals in Heisei-cho, 249 in Matto, and 177 in Katakai, of which 147 (88.6 %), 239 (96.0 %), and 151 (85.3 %), respectively, agreed to participate. In total, 537 of 592 (90.7 %) individuals in these three areas formed the study population. Informed consent was obtained from all participants. This study was approved by the Ethics Committee of Niigata University School of Medicine.

Procedure

Trained nurses in Ojiya interviewed participants in Heisei-cho between October and December 2011, in Matto between August and October 2012, and in Katakai between July and September 2013. Interviewers collected information regarding demographic characteristics, health status (including cognitive function), and lifestyle. Family environment was classified as living with family or alone, and current occupational status was classified as unemployed or employed. Histories of hypertension, cerebrovascular diseases, diabetes, and a family history of dementia were also obtained. Also, we inquired about the extent of property damage caused by the Niigata-Chuetsu earthquake, a large earthquake that hits the Niigata-Chuetsu area of Japan on October 23, 2004 [10]. Property damage was categorized as follows: (1) not damaged, (2) partially damaged (less than half), (3) half or largely (but not completely) destroyed, and (4) completely destroyed according to criteria established by the Japanese government [11].

The revised Hasegawa's dementia scale (HDS-R) was used to assess cognitive function. The HDS-R is a simple 30-point test of general cognitive function. "Cognitively impaired" was defined as an HDS-R score $\leq$20 [12]. The HDS-R was originally used to screen for dementia, with a sensitivity of 0.90 and a specificity of 0.82 using a cutoff point of 20/21, and also correlates well with the mini mental state examination (MMSE) [12]. Like the MMSE,

Table 1 Study area profiles

	Study areas		
	Heisei-cho	Matto	Katakai[a]
Survey year	2011	2012	2013
Residence (urban or rural)	Urban	Rural	Urban
Proportion of farms	0 %	64.0 %	4.8 %
Proportion of people aged $\geq$65 years	32.4 %	36.4 %	34.4 %
Proportion of people using long-term care insurance	16.2 %	18.6 %	21.0 %
Number of people aged $\geq$65 years[b]	166	249	177
Participation rate	88.6 %	96.0 %	85.3 %

[a] The four central subareas, including Ninocho, Chabatake, Omotesannocho, and Inaba, in Katakai were investigated

[b] People using long-term care insurance were excluded

the HDS-R has been used in population-based epidemiologic studies, especially in Asia [13, 14].

Information on frequency and average daily consumption of alcohol was obtained. Alcohol consumption (equivalent to Japanese sake) was classified into five categories: (1) non-drinkers, (2) <7 gou (1 gou is equivalent to 180 mL of sake), (3) 7–13 gou, (4) 14–20 gou, and (5) ≥21 gou per week. Brinkman index was calculated based on the number of cigarettes smoked per day multiplied by the number of smoking years to estimate lifetime smoking history. Smoking status was classified as: (1) non-smoker, (2) light smoker (Brinkman index <675), and (3) heavy smoker (Brinkman index ≥675). A score of 675 was the median of current or past smokers. Usual bedtime and sleeping hours were also recorded. Regarding spare time activities, we asked whether participants played any roles in their family or community and whether they were involved in any activities for pleasure.

Statistical methods

The χ^2 test was used to test for independence of categorical data in bivariate analyses. Prevalence of cognitive impairment was calculated and compared according to the levels of predictor variables by odds ratios (ORs) calculated using a logistic regression analysis. The primary predictor variable was area of residence (urban or rural), and other predictors were demographic characteristics, disease history, lifestyle-related factors, and property damage by the earthquake. ORs, adjusted for age (a continuous variable) and sex, were calculated using multiple logistic regression analyses. Linear trends (*P* for trend) of ORs according to the levels of predictor variables were tested by a logistic regression analysis with discrete variables as predictors and the presence of cognitive impairment as the outcome. Data were analyzed using SAS statistical software (release 9.1.3, SAS Institute Inc., Cary, NC, USA). $P < 0.05$ was considered statistically significant.

Results

The mean age of participants was 75.7 years (SD 7.0). Participant characteristics, by area, are summarized in Table 2. Significant area differences in distribution were detected in job status, bedtime, and activities for pleasure. The prevalence of cognitive impairment was 5/147 (3.4 %) in Heisei-cho, 20/239 (8.4 %) in Matto, 1/151 (0.7 %) in Katakai, and 26/537 (4.8 %) overall.

The prevalence of cognitive impairment was compared according to the levels of predictor variables. Sex- and age-adjusted ORs are presented in Table 3. Men tended to have a higher OR, with marginal significance ($P = 0.0628$). Age was strongly associated with cognitive impairment (*P* for trend <0.0001). The rural area (Matto) had a significantly higher OR (4.04) than those of the urban areas (Heisei-cho and Katakai). Regarding sleep, those with an earlier bedtime (in particular, those who went to sleep before 9 p.m.) had higher ORs. Family environment, disease history, alcohol drinking, smoking, roles in family or community, pleasure activities, and post-earthquake property damage were not significantly associated with the prevalence of cognitive impairment.

Multiple logistic regression analyses were conducted to confirm the independence of variables, including sex, age, residential area, and bedtime (coded as 1, –8:59 p.m. and 2, 9:00 p.m.–). Age (*P* for trend <0.0001) and residential area (OR = 3.57, 95 % CI: 1.33–9.58, $P = 0.0114$) were significantly associated with cognitive impairment, but sex (OR = 2.09, 95 % CI: 0.85–5.10, $P = 0.1081$) and bedtime (OR = 2.06, 95 % CI: 0.83–5.13, $P = 0.1185$) were not.

Discussion

This study is the first to demonstrate a significant rural–urban difference in the prevalence of cognitive impairment in Japan. Cognitive impairment is associated with falls, fall-related injuries [15], osteoporotic fractures [16], frailty [3], decrease levels of activities of daily living [17], and dementia in the elderly. Thus, the increasing number of elderly individuals with cognitive impairment poses a public health burden in terms of medical and care costs in local governments. One strength of our study is that prevalences were compared between rural and urban communities in a city using an exhaustive survey with a sufficiently high participation rate. Many previous epidemiologic studies compared prevalences between rural and urban populations of different geographical regions [8, 18, 19], which may have reflected regional differences rather than rural–urban differences. The present study was designed to overcome this methodological limitation.

This study used the HDS-R to detect those with cognitive impairment. The HDS-R is frequently used in East Asian populations [13, 14], and is similar to the MMSE in its diagnostic accuracy for dementia [20]. One advantage of using the HDS-R over the MMSE is its diagnostic accuracy regardless of education level [20]. The HDS-R, like the MMSE, is a good screening tool for dementia using a cutoff value of 20/21. It can also be used to screen for MCI, although its diagnostic sensitivity for MCI appears to be lower [21, 22]. Accordingly, HDS-R-assessed cognitive impairment generally reflects dementia and MCI.

We did not include those using long-term care insurance who are at a high risk of developing cognitive impairment.

Table 2 Participant characteristics by area of residence (urban or rural)

Characteristics	Urban (n = 306) (Heisei-cho and Katakai)		Rural (n = 240) (Matto)		P value[a]
Age (years)					0.4267
65–69	73	(23.9 %)	51	(21.3 %)	
70–79	138	(45.1 %)	116	(48.3 %)	
80–89	89	(29.1 %)	60	(25.0 %)	
90–99	6	(2.0 %)	13	(5.4 %)	
Family environment					0.8282
Living with family	23	(7.5 %)	17	(7.1 %)	
Living alone	283	(92.5 %)	223	(92.9 %)	
Current job status					0.0337
Unemployed	215	(70.3 %)	151	(62.9 %)	
Employed	89	(29.1 %)	89	(37.1 %)	
Unknown	2	(0.7 %)	0	(0.0 %)	
History of hypertension					0.9722
Absent	151	(49.3 %)	118	(49.2 %)	
Present	155	(50.7 %)	122	(50.8 %)	
History of cerebrovascular diseases					0.8820
Absent	287	(93.8 %)	226	(94.2 %)	
Present	19	(6.2 %)	14	(5.8 %)	
History of diabetes					0.7327
Absent	274	(89.5 %)	217	(90.4 %)	
Present	32	(10.5 %)	23	(9.6 %)	
Family history of dementia					0.3873
Absent	269	(87.9 %)	205	(85.4 %)	
Present	37	(12.1 %)	35	(14.6 %)	
Alcohol consumption[b](gou/week)					0.7638
Non-drinkers	153	(50.5 %)	114	(47.5 %)	
<7	87	(28.7 %)	76	(31.7 %)	
7–14	40	(13.2 %)	37	(15.4 %)	
≥14	23	(7.6 %)	13	(5.4 %)	
Smoking (Brinkman index)					0.7558
Never-smoker	200	(65.4 %)	163	(67.9 %)	
<675	67	(21.9 %)	40	(16.7 %)	
≥675	39	(12.7 %)	37	(15.4 %)	
Bedtime					<0.0001
–8:59 p.m.	25	(8.2 %)	63	(26.3 %)	
9:00–9:59 p.m.	78	(25.5 %)	87	(36.3 %)	
10:00–10:59 p.m.	100	(32.7 %)	60	(25.0 %)	
11:00 p.m.–	103	(33.7 %)	30	(12.5 %)	
Hours of sleep					0.5683
<6	44	(14.4 %)	48	(20.0 %)	
6–6.9	77	(25.2 %)	57	(23.8 %)	
7–7.9	111	(36.3 %)	58	(24.2 %)	
8–8.9	59	(19.3 %)	48	(20.0 %)	
≥9	15	(4.9 %)	29	(12.1 %)	
Having roles in family or community					0.3288
Yes	290	(94.8 %)	223	(92.9 %)	
No	16	(5.2 %)	17	(7.1 %)	

Table 2 continued

Characteristics	Urban (n = 306) (Heisei-cho and Katakai)		Rural (n = 240) (Matto)		P value[a]
Having activities for pleasure					0.0075
Yes	285	(93.1 %)	236	(98.3 %)	
No	21	(6.9 %)	4	(1.7 %)	
Property damage by the 2004 earthquake					0.8137
Not damaged	30	(9.8 %)	30	(12.5 %)	
Partially damaged	218	(71.2 %)	160	(66.7 %)	
Half or largely destroyed	34	(11.1 %)	39	(16.3 %)	
Completely destroyed	17	(5.6 %)	9	(3.8 %)	
Not applicable	7	(2.3 %)	2	(0.8 %)	

[a] Urban–rural differences tested by multiple logistic regression analyses, adjusting for sex

[b] Equivalent to Japanese sake (1 gou of sake is equivalent to about 27-g ethanol)

This may have affected the prevalence of cognitive impairment. However, the prevalence of long-term care insurance use is similar in rural (Matto, 18.6 %) and urban (Heisei-cho and Katakai, 18.7 % on average) areas, and thus the prevalence of cognitive impairment in rural areas remained high when long-term care insurance use was considered.

A number of epidemiologic studies have provided evidence regarding rural–urban differences in the occurrence of dementia and mild cognitive impairment (MCI) [8, 18, 19, 23, 24]. For example, Russ et al. [8] conducted a meta-analysis and provided evidence of an association between rurality and Alzheimer's disease (AD) incidence (OR = 1.64, 90 % CI: 1.08–2.50), although the data were not significant for overall dementia. They also suggested that rural living, especially in one's early life, may affect the risk of developing AD [8]. In recent years, two epidemiologic studies conducted in East Asian countries reported rural–urban differences in MCI prevalence or incidence. Jia et al. [19] reported a higher prevalence of MCI in rural areas compared with urban areas, with a prevalence ratio of 1.5 (95 % CI: 1.4–1.7) in China. Bae et al. [18] reported a hazard ratio of 1.5 (insignificant) in South Korea.

There are a number of possible reasons for the higher prevalence of cognitive impairment observed in rural areas. First, a low education level is recognized as a risk factor for cognitive impairment [25], and is associated with rurality [19, 24]. Although we did not evaluate education level, it may have contributed to the rural–urban differences in cognitive impairment. Other possible contributors include physical and intellectual activities, low levels of which are considered risk factors for cognitive impairment [25, 26]. The mechanism underlying the influence of rural–urban differences on cognitive impairment should be explored in future studies.

In addition to individual factors, the importance of social environment of older adults in relation to cognition has been suggested, and such factors could be associated with rurality. Clarke et al. [7] reported that residence in a neighborhood with community resources, proximity to public transport, and public spaces in good condition, is inversely associated with cognitive impairment.

"Rurality" is a difficult concept to define. One study characterized rural areas by low population density and a traditional agrarian lifestyle [27]. Russ et al. [8] point out the substantial heterogeneity in studies comparing rural and urban areas, due in part to the difficulty of defining rurality. In this context, caution should be exercised when generalizing the results of the present study.

The prevalence of cognitive impairment tended to be higher in men than in women. This observation is inconsistent with the notion that the prevalence of dementia is higher among women in studies conducted in Japan [28, 29]. Nevertheless, a finding similar to ours, i.e., a higher prevalence of MCI in men than in women, was reported by Petersen et al. [30], who hypothesized that men may experience cognitive decline earlier in life but more gradually, whereas women may transition from normal cognition directly to dementia at a later age but more abruptly. Another potential explanation relates to sampling bias, i.e., long-term care insurance users were not included in this study.

Ojiya city was hit by the 2004 Niigata-Chuetsu earthquake, which may have affected the cognitive status of the elderly to some extent. Indeed, in a study following the 2011 Great East Japan Earthquake, a cognitive function of dementia patients who suffered from the disaster declined more relative to a control group [31]. Although we did not detect an association between property damage and cognitive impairment, its effects on cognitive impairment should be studied further in other settings.

Table 3 Odds ratios (ORs) for cognitive impairment (HDS-R ≤20) according to the levels of predictor variables

Predictor variables	Prevalence of cognitive impairment	Adjusted OR[a] (95 % CI)	*P* or *P* for trend
Sex			*P* = 0.0628
Men	16/243 (6.6 %)	2.25 (0.96–5.27)	
Women	10/294 (3.4 %)	1 (Ref.)	
Age (years)			*P* for trend <0.0001
65–69	1/121 (0.8 %)	1 (Ref.)	
70–79	5/250 (2.0 %)	2.46 (0.28–21.25)	
80–89	12/147 (8.2 %)	10.70 (1.37–83.78)	
90–99	8/19 (42.1 %)	87.77 (10.01–769.42)	
Family environment			*P* = 0.3143
Living with family	25/498 (5.0 %)	1 (Ref.)	
Living alone	1/39 (2.6 %)	0.33 (0.04–2.83)	
Area of residence			*P* = 0.0046
Urban area (Heisei-cho and Katakai)	6/298 (2.0 %)	1 (Ref.)	
Rural area (Matto)	20/239 (8.4 %)	4.04 (1.54–10.62)	
Current job status			*P* = 0.4421
Unemployed	22/361 (6.1 %)	1 (Ref.)	
Employed	4/174 (2.3 %)	0.63 (0.19–2.07)	
History of hypertension			*P* = 0.2657
Absent	14/265 (5.3 %)	1 (Ref.)	
Present	12/272 (4.4 %)	0.62 (0.27–1.44)	
History of cerebrovascular diseases			*P* = 0.4350
Absent	24/506 (4.7 %)	1 (Ref.)	
Present	2/31 (6.5 %)	1.86 (0.39–8.75)	
History of diabetes			*P* = 0.4501
Absent	23/484 (4.8 %)	1 (Ref.)	
Present	3/53 (5.7 %)	1.66 (0.45–6.16)	
Family history of dementia			*P* = 0.5046
Absent	24/466 (5.2 %)	1 (Ref.)	
Present	2/71 (2.8 %)	0.60 (0.13–2.70)	
Alcohol consumption[b] (gou/week)			*P* for trend = 0.7363
Non-drinkers	15/263 (5.7 %)	1 (Ref.)	
<7	5/160 (3.1 %)	0.49 (0.14–1.71)	
7–13	3/76 (3.9 %)	0.72 (0.14–3.77)	
≥14	3/35 (8.6 %)	2.59 (0.44–15.30)	
Smoking (Brinkman index)			*P* for trend = 0.5668
Never-smoker	15/360 (4.2 %)	1 (Ref.)	
<675	9/105 (8.6 %)	1.48 (0.48–4.58)	
≥675	2/72 (2.8 %)	0.45 (0.08–2.49)	
Bedtime			*P* for trend = 0.0392
–8:59 p.m.	12/87 (13.8 %)	4.80 (0.93–24.68)	
9:00–9:59 p.m.	7/161 (4.3 %)	1.49 (0.26–8.61)	
10:00–10:59 p.m.	5/158 (3.2 %)	1.44 (0.26-8.11)	
11:00 p.m.–	2/131 (1.5 %)	1 (Ref.)	
Hours of sleep			*P* for trend = 0.1028
<6	2/91 (2.2 %)	1 (Ref.)	
6–6.9	4/130 (3.1 %)	1.63 (0.27–9.82)	
7–7.9	4/167 (2.4 %)	1.06 (0.18–6.22)	
8–8.9	8/105 (7.6 %)	2.48 (0.49–12.69)	

Table 3 continued

Predictor variables	Prevalence of cognitive impairment	Adjusted OR[a] (95 % CI)	*P* or *P* for trend
≥9	8/44 (18.2 %)	5.14 (0.88–30.01)	
Having roles in family or community			$P = 0.1534$
Yes	20/505 (4.0 %)	1 (Ref.)	
No	6/32 (18.8 %)	2.32 (0.73–7.35)	
Having activities for pleasure			$P = 0.3380$
Yes	24/513 (4.7 %)	1 (Ref.)	
No	2/24 (8.3 %)	2.34 (0.41–13.32)	
Property damage by the 2004 earthquake			P for trend = 0.6787
Not damaged	4/59 (6.8 %)	1 (Ref.)	
Partially damaged	19/372 (5.1 %)	1.00 (0.31–3.25)	
Half or largely destroyed	2/72 (2.8 %)	0.97 (0.13–7.35)	
Completely destroyed	1/26 (3.8 %)	0.98 (0.04–21.84)	

[a] Adjusted for sex and age except for predictor variables of “sex” and “age.” “Sex” and “age” were adjusted for age and sex, respectively

[b] Equivalent to Japanese sake (1 gou of sake is equivalent to about 27-g ethanol)

This study has some limitations worth noting. First, the sample size was limited, and thus, potential associations may not have been detected due to insufficient statistical power. Second, we did not evaluate educational level, which is a known risk factor for cognitive impairment. In addition to the educational level, early life factors, such as early life socioeconomic status and adversity, have been pointed out as being associated with an increased risk of dementia-related cognitive impairment [32]. Thus, environmental factors in early life should further be studied. Finally, this study was conducted in a mid-sized city, and thus, our results may not be generalizable to metropolitan areas (e.g., Tokyo).

In conclusion, the prevalence of cognitive impairment was higher in a rural area compared with urban areas in Japan. This regional difference suggests the presence of modifiable factors in relation to cognitive impairment, which should be elucidated in future studies.

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Compliance with ethical standards

Conflict of interest The authors have no conflicts of interest to report.

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