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A Nationwide Survey on the Prevalence of Dementia and Mild Cognitive Impairment in South Korea

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Abstract. We investigated the prevalence of dementia and mild cognitive impairment (MCI) and the factors associate with risk of dementia from a representative nationwide sample of Korean elders. 8,199 randomly-sampled Koreans aged 65 years or older were invited to participate in the Phase I screening assessment using Mini-Mental State Examination by door-to-door home visit, and 6,141 subjects (response rate = 74.9%) responded. Among them, 2,336 subjects were invited to participate in the Phase II diagnostic assessment for dementia and MCI, and 1,673 subjects responded (response rate = 71.6%). Diagnostic

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assessments were administered using the Korean version of the Consortium to Establish a Registry for Alzheimer's Disease Assessment Packet (CERAD-K) Clinical Assessment Battery. The CERAD-K Neuropsychological Assessment Battery was used for diagnosing MCI. Age-, gender-, education-, and urbanicity-standardized prevalence of dementia was estimated to be 8.1% (95% CI = 6.9–9.2) for overall dementia and 24.1% (95% CI = 21.0–27.2) for MCI. Alzheimer's disease (AD) was the most prevalent type (5.7%) followed by vascular dementia (2.0%). Amnestic subtype (20.1%) was much more prevalent than nonamnestic subtype in MCI (4.0%). Older age, being male, lower education level, illiteracy, smoking, and histories of head trauma or depression were associated with increased dementia risk, and alcohol use and moderately intense exercise were associated with decreased dementia risk. We expect numbers of dementia patients to double every 20 years until 2050 in Korea and expect AD to account for progressively more dementia cases in the future.

Keywords: Dementia, mild cognitive impairment (MCI), prevalence, risk, South Korea

INTRODUCTION

With the world population aging, the number of dementia patients worldwide will be increasing rapidly by 2040. However, the rates of increase will not be uniform; the numbers in developed countries will increase by 100% between 2001 and 2040 but by more than 300% in Asian and South American countries [1]. The speed of the population aging in South Korea (hereafter, Korea) is projected to be one of the fastest in the world. Korea will replace Italy as the world's second-oldest country by 2050. Due to this rapidly aging population and its progressive lifestyle westernization, dementia has emerged as a major health problem in Korea [2, 3].

Accurate national estimates of dementia's current and future prevalence are essential for the effective long-term care and medical cost planning that will fall to the National Health Insurance, National Medical Aid Program, National Long-term Care Insurance, and other private insurance programs for elderly adults in Korea. Although 5 epidemiological studies on the prevalence of dementia have been conducted in Korea [4–8], extrapolations from a single city or county of Korea were employed, and thus their prevalence estimates of dementia varied widely (6.4%–10.8%). Sample size was less than 1,000 and response rate was under 30% in some studies [4–6]. Furthermore, only 1 of these studies investigated the prevalence of mild cognitive impairment (MCI) and also the prevalence of dementias other than Alzheimer's disease (AD) and vascular dementia (VD) [4, 9].

We investigated both the prevalence for dementia and MCI and the factors associated with dementia risk among a representative sample of Korean elders who participated in the first nationwide, population-based survey on dementia and MCI in Korea.

METHODS

Sample

The initial sample size (N_S) was estimated to be 4,531 using the following equation;

$$N_S = \frac{1.96^2\ PQW}{E^2 + (1.96^2\ PQW/N_T)}$$

where P, Q, W, E, and N_T refer to the expected prevalence (%) of dementia, 100 – P (%), expected design effect, maximum acceptable random sampling error (%), and the number of total population, respectively [10]. P was assumed to be 6.3% which was the lowest estimated prevalence of dementia in Korea [5]. W was assumed to be 2, and E was set as 1%. The number of Korean elders aged 65 years old or over in 2008 (4, 365, 218) was computed as N_T. Assuming a response rate of 60%, we needed at least 7,551 subjects and determined to recruit about 8,000 individuals at the initial phase.

In order to capture national variations, we selected 15 districts across the country, and 13 hospitals were responsible for conducting the surveys in their nearest districts. The hospitals drew about 500 participants aged 65 years or older from each district, except for one large, mixed urban/rural district, which had 1,000 participants. Then, we randomly selected villages within the districts to cover about 5,000 residents aged 65 years or older, and selected 10% of them as participants through systematic random sampling based on the residential rosters. Finally 8,199 subjects who were living independently in communities or living in institutions such as nursing homes or hospitals were sampled as the participants.

Design

The current study employed a two-stage design to obtain estimates of the prevalence of dementia and MCI.

Initially (Phase I population survey), the Korean version of Mini-Mental State Examination (MMSE-KC) was applied to all survey participants [11]. Persons were then sampled to undergo a second stage evaluation (Phase II diagnostic evaluation) for dementia from all levels of performance on MMSE-KC, which was used only for sampling purposes for Phase II clinical evaluation and not to determine or screen disease status. The participants who responded to the Phase I survey were placed in one of three groups according to their performance in the MMSE-KC using age-, gender-, and education-adjusted norms for Korean elders [12], as follows: poor (MMSE-KC score less than −1.5 standard deviation (SD) of the norm), intermediate (MMSE-KC score between −1.5 and −1.0 SD), and good (MMSE-KC score of −1.0 SD or higher). Then, for the Phase II clinical evaluation, participants were randomly sampled from each group with different group-specific sampling fractions, as follows: 10% for the good, 50% for the intermediate, and 100% for the poor performance group. The sampling fractions were determined to outweigh the poorer cognitive strata, which are likely to include more dementia cases.

The Phase I survey was conducted from May 2008 through October 2008. A total of 8,199 older people sampled were invited to participate in the study by door-to-door home visit, and 6,141 subjects (response rate = 74.9%) responded to a semi-structured interview which consisted of the MMSE-KC, the Korean version of the Geriatric Depression Scale Short form (SGDS-K) [13], demographic characteristics, and checklists for risk factors (Table 1). If the participant alone could not give enough information, reliable informants (spouse, child, other relatives, and close friends, in descending order) were interviewed as well. There were no statistically significant differences in gender- and age distributions between responders and non-responders (p-value = 0.52 and 0.557, respectively).

The Phase II diagnostic evaluation took place from June 2008 through November 2008. 2,336 subjects (367 from the good performance group, 410 from the intermediate group, and 1,559 from the poor group) were invited to participate in the diagnostic evaluation for dementia, and 1,673 subjects (281 from the good performance group, 311 from the intermediate group, and 1,081 from the poor group) responded to this diagnostic evaluation (response rate = 71.6%).

Table 1
Characteristics of participants in the first phase evaluation

Variable	Level	Men (n = 2,445)	Women (n = 3,696)	Total (n = 6,141)
Age	65–69	36.5	29.4	32.2
	70–74	32.9	28.3	30.2
	75–79	18.8	20.4	19.7
	80–84	7.5	12.6	10.5
	85+	4.3	9.4	7.4
Education	None	12.0	44.2	31.3
	1–6 years	35.8	39.6	38.1
	7 years+	52.2	16.2	30.6
Residence	Rural	33.7	34.9	34.4
	Urban	66.3	65.1	65.6
Marital status	Married	85.1	37.9	56.7
	Bereaved & others	14.9	62.1	43.3
Economic status	Not disadvantaged	92.5	88.5	90.1
	Disadvantaged*	7.5	11.5	9.9
Family history**	No	91.5	93.7	92.8
	Yes	8.5	6.3	7.2
Head trauma†	No	87.6	91.0	89.6
	Yes	12.4	9.0	10.4
Illiteracy	No	96.4	78.6	85.7
	Yes	3.6	21.4	14.3
Depression	No	77.6	68.9	72.4
	Yes‡	22.4	31.1	27.6

*Subjects who were covered by the National Medical Aid program; **Presence of dementia within first-degree family members; †Presence of previous head trauma, with loss of consciousness exceeding 10 minutes; ‡Score on the short form of the Geriatric Depression Scale ≥8.

There were no statistical difference in age, gender, and education level among the performance groups (all p-values < 0.05), except that "no education" was significantly more common among respondents in the poor performance group ($p = 0.021$). In this phase, a face-to-face standardized diagnostic interview, physical and neurological examinations were administered to each subject using the Korean version of the Consortium to Establish a Registry for Alzheimer's Disease Assessment Packet (CERAD-K) Clinical Assessment Battery (CERAD-K-C) [11] Geriatric psychiatrists, who had received a certificate for CERAD-K Clinical Assessment Battery (CERAD-K-C) administration from the CERAD-K headquarter. The CERAD-K Neuropsychological Assessment Battery (CERAD-K-N) [11, 12] was also administered by neuropsychologists or trained research nurses. The CERAD-K-N consists of 9 neuropsychological tests, as follows: Verbal Fluency Test, 15-item Boston Naming Test, MMSE-KC, Word List Memory Test, Constructional Praxis Test, Word List Recall Test, Word List Recognition Test, Constructional Recall Test, and Trail Making Test. All instruments were validated in the Korean population. Brain computed tomography or magnetic resonance imaging (T1-weighted, T2-wighted, FLAIR), laboratory tests including complete blood cell count, chemistry profile, serological test for syphilis, echocardiogram, and chest X-ray were conducted for the subjects who were diagnosed to have dementia to determine the subtypes of dementia.

The mean amount of alcohol consumed per day was determined for subjects who indicated that they had "drank alcohol within the last year". One drink was equivalent to a glass of wine, a half pint of beer, or a single measure of spirits. The amount of exercise was evaluated using the metabolic equivalent of task (MET) by determining the mean hours of light, moderate and vigorous exercises in a day in the past year.

The Institutional Review Board of Seoul National University Hospital, Korea, approved this study protocol, and all participants or their family members provided informed consent.

Diagnosis

Dementia was first defined according to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) diagnostic criteria [14]. For the subjects meeting DSM-IV diagnostic features of dementia, subtypes of dementia were further determined; AD according to the criteria of the National Institute of Neurological and Communicative Disorders and Stroke and the Alzheimer's Disease and Related Disorders Association (NINCDS-ADRDA) [15], vascular dementia (VD) according to the criteria of the National Institute of Neurological Disorders and Stroke-Association Internationale pour la Recherche et l'Enseignement en Neurosciences (NINDS-AIREN) [16], dementia of Lewy body (DLB) and Parkinson's disease with dementia (PDD) according to the consensus guideline proposed by McKeith et al. [17], frontotemporal dementia according to the Lund-Manchester consensus diagnostic criteria [18], and alcohol-related dementia (ARD) according to the diagnostic criteria proposed by Oslin et al. [19]. Efforts were made to designate the primary (most important) cause of dementia in each case instead of assigning mixed dementia. Cases with ambiguous causes were classified as dementia not otherwise specified (NOS). MCI was diagnosed according to the consensus criteria from the International Working Group on MCI [20]. The threshold of objective cognitive impairment was set at –1.5 SD of the age-, gender- and education-adjusted norms of the CERAD-K-N for Korean elders [12] and intact functional activity was defined as having 1 or less on the Blessed Dementia Scale included in the CERAD-K-C. Subtypes of MCI were further determined based on the neuropsychological performance; amnestic MCI single domain type (aMCIs), amnestic MCI multiple domain type (aMCIm), nonamnestic MCI single domain type (naMCIs), and nonamnestic MCI multiple domain type (naMCIm).

Statistical analysis

In order to estimate the crude dementia prevalence, we constructed sample weights for individuals, considering the sampling fraction and response rate at the first and second phase. For estimating nationwide prevalence, we constructed weights based on the distributions of gender, age, educational level, and urbanicity from the 2005 National Census data. We estimated the crude and the nationwide prevalence of dementia, MCI, and their subtypes by applying sample weights. PROC SURVEYFREQ of SAS version 9.1 was employed for estimation, which applied Taylor's series expansion to estimate standard errors and confidence intervals (REF1: SAS 9.1.3 Help and Documentation. SAS Institute Inc., Cary, NC). Finally, to identify factors associated with a greater risk of dementia, we employed univariate and multivariate logistic regression models.

RESULTS

Of the 1,673 participants who completed the Phase II evaluation, 351 were diagnosed with dementia (252 AD, 81 VD, 2 DLB, 3 PDD, 2 FTD, 2 ARD, 9 dementia NOS) and 487 were diagnosed with MCI (149 aMCIs, 257 aMCIm, 62 naMCIs, 19 naMCIm). AD accounted for approximately 70.7% of overall dementia and accounted for progressively more of the dementia cases with increasing age, from 58.3% in the age 65–69 group to 88.2% in the age 85+ group.

The crude prevalence rates were estimated as 9.2% (95% CI = 7.9–10.4%) for overall dementia, 6.5% (95% CI = 5.5–7.5%) for AD, 2.3% (95% CI = 1.6–2.9%) for VD, 0.04% (95% CI = 0.00–0.12) for DLB, 0.05% (95% CI = 0.00–0.15) for PDD, 0.05% (95% CI = 0.00–0.16) for FTD, 0.03% (95% CI = 0.00–0.08) for ARD, and 0.20% (95% CI = 0.07–0.34) for dementia NOS (Table 2). The prevalence rate for DLB and PDD was 0.13% (95% CI = 0.01–0.25), and that of dementia other than AD and VD was 0.4% (95% CI = 0.2–0.6). The prevalence of AD doubles, approximately, every five years to age 85 years or older, whereas that of VD reaches a plateau at 75–79 years. The age-, gender-, education-, and urbanicity-standardized prevalence of dementia among Korean elderly aged 65 years or older was estimated as 8.1% (95% CI = 6.9–9.2) for overall dementia, 5.7% (95% CI = 4.8–6.6) for AD, 2.0% (95% CI = 1.3–2.6) for VD, 0.11% (95% CI = 0.00–0.23) for DLB and PDD, 0.03% (95% CI = 0.00–0.08) for FTD, and 0.07% (95% CI = 0.00–0.16) for ARD. The prevalence rate was

Table 2
Estimated prevalence rates of dementia and its subtypes

		Overall	Subtypes		
			Alzheimer's disease	Vascular dementia	Other dementia
Age*	65–69	3.6 (2.5–4.8)	2.1 (1.2–3.0)	1.2 (0.6–1.9)	0.3 (0.0–0.6)
	70–74	5.2 (3.8–6.6)	3.4 (2.2–4.5)	1.6 (0.9–2.3)	0.2 (0.0–0.4)
	75–79	11.3 (8.1–14.6)	6.9 (4.7–9.1)	3.7 (1.6–5.7)	0.8 (0.1–1.4)
	80-84	17.8 (11.6–24.0)	13.2 (8.3–18.1)	3.5 (0.0–7.1)	1.1 (0.1–2.0)
	85+	30.5 (22.1–38.9)	26.9 (19.2–34.7)	3.6 (1.3–5.8)	n.a.
Gender*	Men	8.0 (6.3–9.6)	5.1 (3.8–6.3)	2.5 (1.7–3.3)	0.4 (0.1–0.7)
	Women	9.9 (8.2–11.6)	7.3 (6.0–8.7)	2.1 (1.2–3.1)	0.4 (0.2–0.7)
Education*	None	15.5 (12.5–18.5)	11.5 (9.2–13.8)	3.5 (1.7–5.2)	0.5 (0.1–0.9)
	1–6 years	6.2 (4.4–8.0)	4.5 (2.9–6.1)	1.5 (0.8–2.2)	0.2 (0.0–0.5)
	7+ years	4.0 (2.8–5.1)	2.6 (1.6–3.5)	1.1 (0.6–1.7)	0.3 (0.0–0.5)
Urbanicity	Rural	9.2 (7.7–10.7)	6.5 (5.4–7.6)	2.4 (1.5–3.3)	0.3 (0.1–0.5)
	Urban	9.2 (7.0–11.4)	6.5 (4.6–8.3)	2.1 (1.2–2.9)	0.7 (0.2–1.1)
Crude prevalence*		9.2 (7.9–10.4)	6.5 (5.5–7.5)	2.3 (1.6–2.9)	0.4 (0.2–0.6)
Adjusted prevalence**		8.1 (6.9–9.2)	5.7 (4.8–6.6)	2.0 (1.3–2.6)	0.4 (0.2–0.6)

*Sample weights applied; **Sample weights applied, and age, gender, education, and urbanicity adjusted based on the 2005 National Census; n.a. = not applicable.

Table 3
Estimated prevalence rates* of mild cognitive impairment (MCI) and its subtypes

		Overall	Subtypes			
			Amnestic multiple	Amnestic single	Nonamnestic multiple	Nonamnestic single
Age†	65–69	20.1 (15.3–25.0)	9.3 (6.1–12.4)	7.1 (3.6–10.5)	1.0 (0.0–2.2)	2.8 (1.2–4.5)
	70–74	21.6 (16.3–27.0)	8.7 (5.6–11.7)	10.5 (6.0–15.1)	0.6 (0.2–1.0)	1.9 (0.5–3.3)
	75–79	25.3 (17.4–33.2)	7.6 (4.4–10.9)	11.7 (5.7–17.7)	0.6 (0.0–1.3)	5.3 (0.0–10.7)
	80–84	28.9 (18.5–39.3)	13.8 (5.7–21.9)	7.8 (2.4–13.2)	n.a.	7.3 (0.7–13.9)
	85+	35.6 (23.1–48.2)	18.6 (9.4–27.7)	14.1 (2.9–25.2)	0.5 (0.0–1.5)	2.5 (0.0–7.2)
Gender†	Men	20.1 (15.6–24.6)	8.6 (6.4–10.8)	7.1 (3.8–10.4)	0.6 (0.2–0.9)	3.7 (0.9–6.6)
	Women	25.9 (21.7–30.1)	10.7 (8.0–13.4)	11.2 (7.9–14.4)	0.7 (0.1–1.3)	3.4 (1.7–5.0)
Education†	None	31.5 (25.4–37.5)	14.9 (10.7–19.1)	13.2 (8.5–17.9)	0.5 (0.0–0.9)	2.9 (0.7–5.1)
	1–6 years	25.4 (19.4–31.3)	7.6 (4.8–10.3)	11.5 (6.7–16.2)	1.1 (0.0–2.1)	5.3 (1.8–8.7)
	7+ years	14.9 (11.0–18.7)	7.8 (5.0–10.5)	4.4 (2.3–6.6)	0.3 (0.1–0.6)	2.3 (0.6–4.0)
Urbanicity	Rural	20.5 (16.9–24.1)	7.9 (5.7–10.1)	9.8 (6.9–12.7)	0.3 (0.1–0.6)	2.5 (1.1–3.9)
	Urban	30.5 (24.5–36.5)	14.2 (10.5–17.9)	9.4 (5.3–13.6)	1.3 (0.1–2.4)	5.6 (2.0–9.1)
Crude prevalence†		23.7 (20.6–26.8)	9.9 (8.1–11.8)	9.7 (7.3–12.0)	0.6 (0.2–1.0)	3.5 (2.0–5.0)
Adjusted prevalence‡		24.1 (21.0–27.2)	10.4 (8.4–12.4)	9.7 (7.3–12.0)	0.7 (0.2–1.1)	3.3 (2.0–4.7)

*95% confidence intervals are presented in the parentheses; †Sample weights applied; ‡Sample weights applied, and age, gender, education, and urbanicity adjusted based on the 2005 National Census; n.a. = not applicable.

highest for mild dementia (CDR = 1; 3.12%), followed by very mild dementia (CDR = 0.5; 2.29%), moderate dementia (CDR = 2; 1.47%), and severe dementia (CDR ≥ 3; 1.07%).

The crude prevalence rates were estimated as 23.7% (95% CI = 20.6–26.8) for overall MCI, 9.7% (95% CI = 7.3–12.0) for aMCIs, 9.9% (95% CI = 8.1–11.8) for aMCIm, 3.5% (95% CI = 2.0–5.0) for naMCIs, and 0.6% (95% CI = 0.2–1.0) for naMCIm. The amnestic subtype was more prevalent than the nonamnestic subtype. Prevalence of amnestic MCI increased with advancing age, whereas that of nonamnestic MCI did not. The age-, gender-, education-, and urbanicity-standardized prevalence of MCI was estimated to be 24.1% (95% CI = 21.0–27.2) (Table 3).

In our univariate logistic models, older age, being female, having fewer years of education, rural residence, lower income, illiteracy, smoking, and histories of head trauma and depression were associated with an increased dementia risk, and alcohol use and exercise were associated with decreased dementia risk (Table 4). Of these factors, the multivariate model showed that older age, fewer years of education, illiteracy, smoking, and histories of head trauma, depression, alcohol use, and exercise remained significant and the gender effect reversed (i.e., women were at lower risk of dementia) (Table 5). The univariate and multivariate logistic regression models for AD and VD were similar to those for dementia as a whole.

DISCUSSION

The Delphi consensus study reported that estimates of dementia prevalence for the Asian nations were lower than those for the United States and Europe [1]. Latin America had the highest standardized prevalence (8.50%), and East Asia had the lowest (4.98%). However, research (including the present study) has consistently shown the overall prevalence of dementia in Korea to be higher (6.4%–10.8%) [5–9] than that reported from Western countries [1, 21] as well as from other Asian countries, including Japan (4.7–6.7%) [22, 23], China (1.8–6.1%) [24, 25], and India (2.4%) [26]. Variability in the prevalence estimates between coun-

Table 4
Factors associated with the risk of dementia in univariate logistic regression models

Variable	Level	Dementia		Alzheimer's disease		Vascular dementia	
		Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Age (years)	65–69	1.00	–	1.00		1.00	
	70–74	1.49	(1.13–1.96)	1.67	(1.18–2.37)	1.37	(0.86–2.19)
	75–79	3.75	(2.87–4.9)	3.98	(2.83–5.61)	3.57	(2.28–5.59)
	80–84	7.00	(5.31–9.23)	9.03	(6.42–12.7)	4.10	(2.48–6.78)
	≥85	18.86	(14.05–25.31)	28.94	(20.42–41.02)	6.49	(3.64–11.56)
Gender	Men	1.00	–	1.00		1.00	
	Women	1.39	(1.19–1.64)	1.62	(1.33–1.97)	0.95	(0.71–1.28)
Residence	Urban	1.00	–	1.00		1.00	
	Rural	1.17	(1.00–1.38)	1.16	(0.96–1.41)	1.03	(0.74–1.41)
Economic status	Not disadvantaged	1.00	–	1.00		1.00	
	Disadvantaged*	2.34	(1.88–2.92)	2.31	(1.79–2.98)	2.06	(1.32–3.23)
Education (years)	≥7	1.00	–	1.00		1.00	
	1–6	1.86	(1.45–2.38)	2.07	(1.53–2.8)	1.56	(0.98–2.5)
	0	6.00	(4.79–7.51)	6.89	(5.25–9.03)	4.66	(3.08–7.07)
Illiteracy	No	1.00	–	1.00		1.00	
	Yes	9.43	(7.83–11.36)	10.50	(8.53–12.91)	6.53	(4.59–9.28)
Smoking	No	1.00		1.00		1.00	
	Yes	1.57	(1.27–1.93)	1.55	(1.21–1.97)	1.55	(1.02–2.35)
Alcohol (standard units/day)	0	1.00		1.00		1.00	
	≤1	0.68	(0.53–0.87)	0.57	(0.42–0.77)	0.91	(0.59–1.43)
	≤2	0.25	(1.12–0.52)	0.34	(0.16–0.71)	n.a.	–
	≥3	0.60	(0.43–0.84)	0.63	(0.43–0.92)	0.51	(0.24–1.06)
Exercise (MET)	Mild	1.00		1.00		1.00	
	Moderate	0.27	(0.21–0.32)	0.29	(0.23–0.36)	0.22	(0.14–0.32)
	Severe	0.31	(0.19–0.51)	0.26	(0.14–0.49)	0.26	(0.10–0.72)
Head trauma†	No	1.00	–	1.00		1.00	
	Yes	2.01	(1.59–2.55)	1.66	(1.24–2.21)	2.89	(1.92–4.33)
Depression‡	No	1.00	–	1.00		1.00	
	Yes	4.11	(3.47–4.88)	4.15	(3.42–5.05)	3.86	(2.76–5.42)

CI = Confidence intervals; MET = Metabolic Equivalent of Task; n.a. = Not applicable; *Covered by National Medical Aid; †Presence of previous head trauma with loss of consciousness longer than 10 minutes; ‡Score on the short form of the Geriatric Depression Scale ≥8.

Table 5
Factors associated with the risk of dementia in a multivariate logistic regression model

Variable	Level	Dementia		Alzheimer's disease		Vascular dementia	
		Odds ratio	95% CI	Odds ratio	95% CI	Odds ratio	95% CI
Age (years)	65–69	1.00	–	1.00	–	1.00	–
	70–74	1.39	(1.00–1.94)	1.54	(1.03–2.30)	1.21	(0.66–2.24)
	75–79	2.86	(2.06–3.98)	2.95	(1.98–4.40)	3.06	(1.73–5.43)
	80–84	4.79	(3.39–6.77)	6.07	(4.02–9.17)	3.68	(1.94–6.97)
	≥85	6.71	(4.51–9.97)	9.77	(6.21–15.38)	2.21	(0.98–4.97)
Gender	Men	1.00	–	1.00	–	1.00	–
	Women	0.42	(0.31–0.55)	0.45	(0.32–0.63)	0.30	(0.18–0.49)
Residence	Urban	1.00	–	1.00	–	1.00	–
	Rural	1.17	(0.93–1.47)	1.17	(0.90–1.53)	0.99	(0.64–1.53)
Economic status	Not disadvantaged	1.00	–	1.00	–	1.00	–
	Disadvantaged*	1.27	(0.94–1.70)	1.20	(0.85–1.68)	1.45	(0.85–2.48)
Education (years)	≥7	1.00	–	1.00	–	1.00	–
	1–6	1.23	(0.90–1.68)	1.08	(0.74–1.56)	1.95	(1.07–3.54)
	0	1.87	(1.32–2.63)	1.55	(1.03–2.32)	4.38	(2.29–8.38)
Illiteracy	No	1.00	–	1.00	–	1.00	–
	Yes	4.68	(3.57–6.15)	5.68	(4.20–7.70)	2.15	(1.28–3.63)
Smoking	No	1.00	–	1.00	–	1.00	–
	Yes	1.91	(1.42–2.56)	2.05	(1.46–2.89)	1.83	(1.06–3.17)
Alcohol (standard units/day)	0	1.00	–	1.00	–	1.00	–
	≤1	0.69	(0.50–0.95)	0.60	(0.41–0.89)	0.68	(0.39–1.20)
	≤2	0.22	(0.10–0.46)	0.30	(0.14–0.66)	n.a.	–
	≥3	0.47	(0.31–0.72)	0.53	(0.33–0.87)	0.27	(0.11–0.65)
Exercise (MET)	Mild	1.00	–	1.00	–	1.00	–
	Moderate	0.49	(0.39–0.61)	0.50	(0.39–0.66)	0.40	(0.26–0.62)
	Severe	0.99	(0.55–1.75)	0.88	(0.44–1.76)	0.35	(0.07–1.67)
Head trauma†	No	1.00	–	1.00	–	1.00	–
	Yes	2.26	(1.69–3.00)	1.88	(1.33–2.66)	2.68	(1.65–4.35)
Depression‡	No	1.00	–	1.00	–	1.00	–
	Yes	3.08	(2.50–3.81)	3.14	(2.46–4.01)	2.46	(1.67–3.62)

CI = Confidence intervals; MET = Metabolic Equivalent of Task; n.a. = Not applicable; *Covered by National Medical Aid; †Presence of previous head trauma with loss of consciousness exceeding 10 minutes; ‡Score on the short form of the Geriatric Depression Scale ≥8.

tries may be attributable to methodological differences, such as variations among study designs and diagnostic thresholds for dementia, or to true differences in population characteristics, such as incidence of dementia, mortality after the onset of dementia, and/or the demographics of the examined society. Regarding dementia, Korea has been transitioning rapidly from a high incidence-high mortality-low recognition to a low incidence-low mortality-high recognition society. Furthermore, it may be in the high incidence-low mortality-high recognition stage currently, which may have contributed, at least in part, to the high-prevalence dementia estimates in Korea [27, 28].

Although some early studies from South-East and East Asian countries reported equal distributions of AD and VD, more recent research, including the present study, suggests AD has become the most prevalent subtype of dementia due to the inhabitants' increasing longevity and better physical health; AD, the onset of which is in general later than that of VD, increases as the number of very old people increases, while better physical health reduces the number of stroke sufferers and thus the number with VD [28]. With Korea's rapid transition from an aging society to an aged society [2], the number of dementia patients is expected to double every 20 years until 2050 (0.47 million in 2010, 1.14 million in 2030, 2.13 million in 2050). Furthermore, AD is expected to account for progressively more dementia cases in the future, since the prevalence of AD increased consistently with age until 85 years or older, whereas that of VD peaks at age 75–79 years old and then decreases thereafter.

To our knowledge, this is the first report that investigated the prevalence of rare dementia (DLB, FTD and ARD) simultaneously in community-dwelling Korean elders. The prevalence of DLB has been found to be very low in population-based studies [29–31]. For example, the prevalence of DLB in an elderly Japanese population was estimated to be 0.1% [31]. In our previous work that adapted the same diagnostic hierarchy as we did in the current study, the prevalence of DLB was estimated to be 0.4% which was about four times

higher than that of DLB and PDD in the present study (0.13%). This discrepancy seems to be attributed to the difference in the study design; we adopted a single-phase design in the previous work [4], whereas a two-phase design in the present study. Compared with the two-phase design, the single-phase design may be more sensitive to the rare types of dementia in which memory impairment is not as prominent as in AD since it avoided the use of brief cognitive tests for screening dementia. The prevalence of FTD in the current study was somewhat lower than that in Japanese (0.11) [32] or Spanish (0.30%) [30]. Although this discrepancy may be attributed to either methodological differences between the studies or true ethnic differences, differences in the diagnostic strategy may have played a key role since we did not allow the diagnose of mixed dementia and put AD in the higher diagnostic hierarchy than other types of dementia. For example, when a subject met the criteria for possible AD and possible FTD simultaneously, he/she were diagnosed as AD in the present study.

Population-based studies estimate that the prevalence of MCI is more than double that of dementia [33]. The present study found almost one-fourth of Korean elders aged 65 years or older had MCI, which was quite comparable to our previous work on an urban population of elderly Koreans [9]. In more than 20 previous community-based epidemiological MCI studies, prevalence rates varied widely [33, 34]. Additionally, another study found that this wide variance was considerably attributed to the differences in the diagnostic criteria and their operations between studies [9]. The revision of the diagnostic criteria for MCI by the International Working Group on MCI may increase the prevalence estimates of MCI since this revision expands the MCI construct, from a pre-AD condition to a pre-dementia condition, by introducing the nonamnestic subtypes [20]. The numbers and types of neuropsychological tests applied may have considerable influence on overall prevalence estimates and subtype distributions [9]. In the current study, amnestic subtypes accounted for more than three-fourths of all MCI patients and more than 90% of MCI patients aged 85 years or older. This corresponds well to findings that AD accounted for most of our dementia patients and its prevalence consistently increased with advancing age, since amnestic MCI appears most closely linked with AD [35, 36]. In addition, 93.7% of multiple domain subtype was amnestic, suggesting that MCI patients in this age group eventually may encounter memory impairment regardless of the underlying causes.

There has been conflicting evidence regarding gender differences in dementia risk. In a recent meta-analysis, gender was independently associated with dementia risk in all regions other than North America and Pacific Asia [28]. The present study found women to be at higher risk for dementia in univariate analysis but lower risk for dementia in multivariate analysis, suggesting uncontrolled risk factors may have confounded previous observations on gender-related dementia risk. Gender differences in mental health have been often attributed to gender-related differences in social exposures [37]. Over the past few decades, however, rapid social and economic changes, such as expansions of formal education and women's labor force participation, have had profound implications for Korean women [38], which possibly contributed to the reversal of the gender effect on dementia risk in the multivariate analysis.

Illiteracy rates are still high in Korean elders [2]. The rate was 14.3% in the present study. Illiteracy was independently associated with the risk of dementia after adjusting for educational level, indicating that lack of literacy may influence dementia risk beyond the influence of lack of formal education *per se*. Literacy was strongly associated with cognitive function across all cognitive domains, even in well-educated elders [39], and may contribute to the development of a cognitive reservoir. If this is the case, interventions to improve lifetime literacy may help prevent dementia.

Reportedly, regular exercise also reduces the risk of dementia and AD in the elderly, by as much as 40% [40]. However the protective effect of exercise against dementia has not been consistently replicated [41], which may possibly be attributable to differences in intensity and/or type(s) of exercise(s) among studies. In particular, engaging in more diverse physical activities was associated with a reduced risk for dementia in the Cardiovascular Health Study [42], and, in the current study, the risk of dementia was lowest for those engaging in a moderate amount of exercise. Light to moderate amount of alcohol consumption was also associated with low risk of dementia. In a recent meta-analysis, relative risks of dementia for light to moderate drinkers compared with nondrinkers were 0.74 (95% CI = 0.61–0.91), suggesting that alcohol drinkers in late life have reduced risk of dementia. However it is unclear whether this reflects selection effects in cohort studies commencing in late life, a protective effect of alcohol consumption throughout adulthood, or a specific benefit of alcohol in late life [43].

In consistent with previous studies [44, 45], a history of head trauma was also associated with dementia

risk in the present study. Although this association may be attributed to head trauma-induced upregulation of amyloid-β protein precursor and neuronal loss [46], it may be attributed to selective recall bias since many prospective studies failed to find a significant association between dementia and head trauma [47].

Depression was associated with the dementia risk in the present study. A meta-analysis by Jorm suggested that a history of depression nearly doubles the risk of dementia, as found by both case-control studies (RR = 2.01, 95% CI = 1.16–3.50) and prospective cohort studies (RR = 1.87, 95% CI = 1.09–3.20) [48]. However, it remains controversial whether a history of depression leads to an increased risk of dementia or not. Relationship between depression and dementia is much more complex; depression may be a risk factor for dementia or a symptom or prodrome of dementia. In a recent co-twin control analysis, which controlled for genetic and early environmental risk factors shared by twins, twins with a history of depression were three times more likely to have dementia compared to their co-twin, suggesting that increased likelihood of dementia associated with depression may not be attributed to shared genes or shared early life influences. Furthermore, depression occurring more than 10 years before dementia onset was no longer associated with the risk of dementia in contrast to depression occurring within 10 years before dementia onset. These results suggested that late-life depression may not be a risk factor but a prodrome of dementia [49].

This study has several strengths: a representative sample of Korean elders aged 65 years or older; a good participation rate; a sizeable sample over the age of 85; the inclusion of long-term care residents; a wide variance in the participants' educational attainments; and simultaneous assessment of dementia and MCI, in which each shares a diagnostic border with the other. In addition, this study minimized diagnostic variability between study sites since all research geropsychiatrists were certified for CERAD-K assessment via formal training programs provided by the CERAD-K headquarter. This study also has some limitations: the two-phase design, which may be less sensitive to non-AD dementia than a single-phase design is; the exclusion of mixed diagnoses, which may result in overestimating prevalence of AD and underestimating that of non-AD dementia; non-responders may have poorer health status than responders, which may result in underestimating prevalence of dementia; and the failure to consider certain known dementia risk factors, such as the apolipoprotein E genotype, vascular factors or behavioral symptoms.

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