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A 9-Year Comparison of Dementia Prevalence in Korea: Results of NaSDEK 2008 and 2017

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Abstract.
Background: In many high-income Western countries, the prevalence of dementia had been reduced over the past decades.
Objective: We investigated whether the prevalence of all-cause dementia, Alzheimer's disease, vascular dementia, and mild cognitive impairment (MCI) had changed in Korea from 2008 to 2017.
Methods: Nationwide Survey on Dementia Epidemiology of Korea (NaSDEK) in 2008 and 2017 was conducted on representative elderly populations that were randomly sampled across South Korea. Both surveys employed a two-stage design (screening and diagnostic phases) and diagnosed dementia and MCI according to the fourth edition of the Diagnostic and Statistical Manual of Mental Disorders and the consensus criteria from the International Working Group, respectively. The numbers of participants aged 65 years or older in the screening and diagnostic phases were 6,141 and 1,673 in the NaSDEK 2008 and 2,972 and 474 in the NaSDEK 2017, respectively.
Results: The age- and sex-standardized prevalence of all-cause dementia and Alzheimer's disease showed nonsignificant decrease (12.3% to 9.8%, odds ratio [OR] = 0.89, 95% confidence interval [CI] = 0.54–1.48 for all-cause dementia; 7.6% to 6.8%, OR [95% CI] = 0.91 [0.58–1.42] for Alzheimer's disease). Vascular dementia decreased in the young-old population aged less than 75 years (2.7% to 0.001%, OR [95% CI] = 0.04 [0.01–0.15]) and in women (1.9% to 0.5%, OR [95% CI] = 0.27 [0.10–0.72]) while MCI remained stable (25.3% to 26.2%, OR [95% CI] = 1.08 [0.67–1.73]).
Conclusion: We found that the prevalence of dementia in Korea showed a nonsignificant decrease between 2008 and 2017.

Keywords: Alzheimer's disease, dementia, mild cognitive impairment, prevalence, vascular dementia

INTRODUCTION

In high-income Western countries, several studies reported that, over the last two decades, the prevalence [1–3] or incidence [4] of dementia seemed to have decreased. However, other studies suggested a worsening cognitive function [5] or an increase in the risk of cognitive impairment [6] over time. In East Asian countries, the prevalence estimate has increased in Japan [7–9], and remained stable in South Korea (hereafter, Korea) [10] and China [11] over the last two to three decades. Although there may be substantial socio-environmental contributions to these geographical differences in the secular trends [12–16], population-based epidemiological studies from Asian countries have suffered from several methodological drawbacks. First, none were conducted using a representative nationwide sample [7–9, 11]. Second, some studies made a simple comparison of the estimated value of the prevalence between two time points to determine its secular trend, not using a regression model, for example [17, 18], or did not employ a proper weighting method to account for the response rate or sampling fraction when calculating the prevalence [18]. Third, they rarely examined the trend in the prevalence of dementia by its subtypes after 2010.

Mild cognitive impairment (MCI) is a high-risk condition for dementia, shares a diagnostic border with dementia, and can pose a substantial health burden [19]. Although the prevalence of MCI was reported to be stable in recent decades in the US [20] and UK [21], its trend has never been investigated in Asian countries.

As for this matter, Korea is deemed ideal for the population-based epidemiological study because of its relatively homogenous composition in terms of ethnicity and language use [22], with the latest estimates of the prevalence and incidence of dementia being 9.8% [23] and 16.2 cases per 1,000 person-year [24], and those of MCI being 26.2% [23] and 28.1 cases per 1,000 person-year [25]. Korea has undergone a characteristics population structure change with a steady increase in the proportion of the working-age population aged 15 to 64 between 1985 and 2015 owing to the late 1950 s and early 1960 s baby boomers [26]. Additionally, a longer life expectancy due to improved health conditions, a low fertility rate, and increased educational attainment are all expected to drastically increase the percentage of the elderly population in the coming decades [26]. Therefore, it is worth investigating the trends in the prevalence rate of dementia and MCI reflecting these unique population structure changes of this country.

In this study, we investigated changes in the prevalence of all-cause dementia, Alzheimer's disease (AD), vascular dementia (VaD), and MCI over 9 years in Korea using data from the Nationwide Survey on Dementia Epidemiology of Korea (NaSDEK) conducted in 2008 and 2017. We hypothesized that, similar to that of Western countries, the prevalence of all-cause dementia, AD, and VaD decreases while that of MCI remains stable.

METHODS

Data, participants, and study design

The NaSDEK 2008 was conducted from May 2008 to November 2008 [27] and the NaSDEK 2017 from June 2016 to June 2017 [23] with support from the Ministry of Health and Welfare to monitor the prevalence and risk factors of dementia and MCI in elderly Koreans. Both studies employed a two-stage design: screening cognitive impairments (phase I), followed by diagnosing dementia and MCI (phase II).

We determined the number of participants to be approached at the screening, N_S, using the following equation [28]:

$$\sigma^2 = P \times (1 - P)$$

$$N_S = \frac{Z^2 \times \sigma^2 \times W}{(E^2 + (Z^2 \times \sigma^2 \times W \div N_T)) \times R}$$

where σ^2 is the sample variance, P is the expected prevalence of dementia, Z is the Z statistic for a level of confidence, W is the expected design effect, E is the maximum acceptable random sampling error, N_T is the total number of the elderly population, and R is the expected response rate. As we assumed a 95% confidence level, Z was set at 1.96. Remaining parameters were P = 0.063, $W = 2$, $E = 0.01$, $N_T = 4{,}365{,}218$, and $R = 0.6$ for NaSDEK 2008 and P = 0.0777, $W = 2$, $E = 0.01414$, $N_T = 9{,}748{,}562$, and $R = 0.55$ for NaSDEK 2017 (for the rationale and sources of each parameter, see Supplementary Table 1). As a result, the sample sizes needed to be approached for NaSDEK 2008 and 2017 were estimated at 7,551 and 5,005, respectively.

Both the NaSDEK 2008 and 2017 used 6 regions as primary sampling units with a geographical spread covering the entire country accounting for the rural/urban ratio. Using a systematic random sampling method, both surveys drew on the resident registration system, the official national identification system of Korea. The size of the sample selected from each region was determined to be proportional to the number of the elderly population in that region, based on the probability proportional sampling method. Finally, we approached 8,199 and 5,056 participants in the NaSDEK 2008 and 2017, respectively. The NaSDEK 2008 included those aged 65 or older, while the NaSDEK 2017 included those aged 60 or older to conform to the National Dementia Plans at that time. The study protocols of the NaSDEK 2008 and 2017 were approved by the Institutional Review Board of Seoul National University Hospital and Seoul National University Bundang Hospital, respectively, and fully informed written consent was obtained from all participants or their family members.

Procedures

The NaSDEK 2008 and NaSDEK 2017 were multi-center studies with 15 and 22 hospitals across South Korea involved, respectively. In phase I, for individuals who agreed to participate in the survey, we invited them to each regional hospital or visited the participants' residence in case they were unable to ambulate. Approximately 5–10 interviewers of psychologists, nurses, and social workers from

each hospital who were trained on the survey questionnaires gathered demographic information, and delivered standardized interviews composed of the Korean version of the Mini-Mental State Examination (MMSE) [29, 30] and the Korean version of the Geriatric Depression Scale – Short Form (SGDS-K) [31]. According to MMSE performance, the participants were stratified into three subgroups: poor with a z score of <-1.5, good with a z score of ≥ -1.0, and intermediate with the z score between them. We calculated z scores using the age-, sex-, and education-adjusted normative data of MMSE for elderly Koreans [30, 32]. We then randomly sampled 10% of the good, 50% of the intermediate, and 100% of the poor group to make the selection probability comparable among the three performance groups, and again invited them to phase II at each regional hospital or visited their residence if necessary.

In phase II, geropsychiatrists or neurologists who were experts in dementia research delivered the standardized diagnostic interview based on the Korean version of the Consortium to Establish a Registry for Alzheimer's Disease Assessment Packet – Clinical Assessment Battery (CERAD-K-C) [33]. It is composed of a comprehensive history taking, mental status examination, and physical and neurological examinations to assess the cognitive function and to ascertain its natural course. Subsequently, neuropsychologists or trained nurses administered the CERAD-K Neuropsychological Assessment Battery (CERAD-K-N) [32, 33]. The CERAD-K-N comprises the Verbal Fluency Test, 15-item Boston Naming Test, Word List Memory Test, Constructional Praxis Test, Word List Recall Test, Word List Recognition Test, Constructional Recall Test, and Trail Making Test, which were all validated for Korean elderly.

Building on these data, we made a diagnosis of dementia according to the Diagnostic and Statistical Manual of Mental Disorders, Fourth Edition (DSM-IV) [34]. If an individual is found to have dementia, we conducted further diagnostic evaluations to determine its subtype that include laboratory tests such as complete blood cell count, a chemistry profile, and a serological test for syphilis, electrocardiogram, chest X-ray, and brain computed tomography or magnetic resonance imaging. This procedure was based on the following criteria: 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 [35], VaD 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) [36], dementia with Lewy bodies and Parkinson's disease with dementia according to the consensus guideline proposed by McKeith et al. [37], frontotemporal dementia according to the Lund-Manchester consensus diagnostic criteria [38], and alcohol-related dementia according to the diagnostic criteria proposed by Oslin et al [39]. We attempted to designate a single primary cause of dementia in each case instead of making a mixed type diagnosis based on the NINDS-AIREN guidelines stating that the term mixed dementia should be discouraged for epidemiological studies. We classified the cases with ambiguous subtypes as dementia, not otherwise specified. We diagnosed MCI according to the consensus criteria from the International Working Group on MCI [40]. The objective cognitive impairment of MCI was defined as a z score of <-1.5, calculated using the age-, sex-, and education-specific norms of the CERAD-K-N for elderly Koreans [32]. We defined the intact functional activity of the participants as having the Blessed Dementia Scale [41] score ≤ 1 which was a part of CEARD-K-C. We made the final diagnosis of each participant through a consensus diagnostic conference which involves at least three geropsychiatrists or neurologists and the principal investigator at each regional hospital.

Assessment of covariates

We included the following demographic variables in the regression analyses as covariates: age, sex, years of formal education, living area, and socioeconomic status (SES). The living area was categorized into either the rural or urban area. If an official address of a participant was registered as '-eup', '-meyon', or '-ri', we determined his/her living area as rural, and the rest of the cases as urban. Regarding the SES, disadvantaged status was designated for those who reported themselves to have been covered by the National Medicaid Program.

Statistical analyses

Demographic characteristics were stratified by 5-year age bands (65–69 years, 70–74 years, 75–79 years, 80–84 years, and 85 years and older), sex (men versus women), years of education (without formal education, 0 years; primary school, 1–6 years; and middle school or higher, 7 years or more), living

area (rural versus urban), and SES (not disadvantaged versus disadvantaged).

We used inverse probability weighting methods to estimate the prevalence of dementia and MCI separately. To calculate weights, we took into consideration the sampling fraction and response rate of phases I and II. For the 2017 survey, we employed weighted sampling for the elderly aged 80 years or older to account for the expected increase of non-response in this age group and eliminated those aged 60–64 years from our analyses to match the age range with the 2008 survey.

In order to compare the prevalence between 2008 and 2017, the adjusted prevalence from each time-point was age- and sex-standardized to the 2015 population structure by 5-year age bands using direct standardization. Because the National Statistical Office in Korea conducts the Population and Housing Census every 5 years, the 2015 population structure was the most recent and available data, and thus used as the reference structure. To ascertain the existence of a statistical difference between the 2008 and 2017 prevalence, we constructed four separate weighted logistic regression models each of which had a binary dependent variable indicating whether an individual was diagnosed with all-cause dementia, AD, VaD, or MCI, respectively, and an independent variable, the year of observation, with a value of 0 indicating 2008 and 1 indicating 2017. These four models were adjusted for five covariates mentioned above which are known to be related to the risk of dementia [42]. We also examined the interaction between each of these five covariates and the year of observation, and if an interaction term was significant, we planned to conduct a subgroup analysis stratified by the corresponding covariate. In this case, we performed additional analyses with each of the remaining covariates added consecutively under a series of models to show the robustness of the result and to measure the effect of each covariate variation on the outcome.

All data on the population structure were obtained from the Korean Statistical Information Service. Prevalence was estimated using Survey Procedure (PROC SURVEYFREQ) of SAS (University Edition) software (SAS Institute Inc., Cary, NC) with Taylor's series expansion to calculate standard errors and confidence intervals. The comparison of prevalence between the year of observation was conducted using the *Survey* package [43] of R Statistical Software (version 3.5.1; R Foundation for Statistical Computing, Vienna, Austria).

Data availability statement

Datasets utilized in the current analyses will be shared in an anonymized form by a request from qualified investigators.

RESULTS

The demographic characteristics of the participants are summarized in Table 1. The response rates to the screening and diagnostic phases, respectively, were 74.9% and 71.6% for the NaSDEK 2008, and 73.2% and 62.0% for NaSDEK 2017. A detailed description of the distribution of the sample sizes for each geographical region is shown in Supplementary Table 2. Of the 3,703 individuals who responded to the phase I screening in the NaSDEK 2017 survey, 731 were excluded because they were younger than 65 years old, and the remaining 2,972 individuals were included in our analyses. Compared to the NaSDEK 2008, the proportions of the participants who were aged 65–69 years, men, not formally educated, living in rural areas, and socioeconomically disadvantaged were lower in the NaSDEK 2017 ($p < 0.001$ for all cases by chi square tests; Table 1).

Table 2 shows the number and weighted percentages of people with all-cause dementia, AD, VaD, and MCI in the NaSDEK 2008 and 2017. The age- and sex-standardized prevalence of all-cause dementia, AD, and VaD estimated by the NaSDEK 2017 were lower, while that of MCI was higher, than those estimated in the NaSDEK 2008. However, the differences were not substantial ($p = 0.665$ for all-cause dementia, $p = 0.675$ for AD, $p = 0.984$ for VaD, and $p = 0.751$ for MCI by the weighted regression models accounting for age, sex, years of education, place of residence, and SES).

There were no significant interactions between the year of observation and the covariates computed in the regression models for all-cause dementia, AD, and MCI. However, in the regression model for VaD, an interaction of the year of observation with the age group and sex was observed ($p < 0.001$ for the interaction between age groups and the year of observation; $p = 0.041$ for the interaction between sex and the year of observation). In the subsequent subgroup analyses, the prevalence estimates of VaD decreased from 2.4% to 0.1% in the 70–74 year age group ($p = 0.003$) and from 1.9% to 0.5% in women ($p = 0.009$) over the 9-year interval. In the 65–69 year age group, the prevalence estimate of VaD was 3.0% in the NaSDEK 2008, but no VaD case was identified in the NaSDEK

Table 1
Demographic characteristics of the participants

	NaSDEK 2008		NaSDEK 2017	
	Screening phase (N = 6,141)	Diagnostic phase[a] (N = 1,673)	Screening phase (N = 2,972)	Diagnostic phase[a] (N = 474)
Age (y)				
65 – 69	1,977 (32.2)	479 (33.7)	708 (23.8)	83 (30.0)
70 – 74	1,855 (30.2)	523 (29.1)	659 (22.2)	92 (30.6)
75 – 79	1,210 (19.7)	323 (20.1)	548 (18.4)	97 (21.2)
80 – 84	645 (10.5)	177 (11.1)	669 (22.5)	103 (11.2)
85+	454 (7.4)	171 (6.0)	388 (13.1)	99 (7.0)
Sex				
Men	2,445 (39.8)	733 (40.9)	1,228 (41.3)	193 (37.5)
Women	3,696 (60.2)	940 (59.1)	1,744 (58.7)	281 (62.5)
Education (y)				
0	1,922 (31.3)	579 (33.6)	566 (19.1)	121 (29.5)
1 – 6	2,340 (38.1)	545 (33.6)	1,041 (35.0)	149 (35.2)
7+	1,879 (30.6)	549 (32.8)	1,365 (45.9)	204 (35.3)
Living area				
Urban	4,028 (65.6)	1,067 (49.6)	2,158 (72.6)	322 (50.2)
Rural	2,113 (34.4)	606 (50.4)	814 (27.4)	152 (49.8)
SES				
Not disadvantaged	5,533 (90.1)	1,484 (84.8)	2,718 (91.5)	416 (94.4)
Disadvantaged[b]	608 (9.9)	189 (15.2)	254 (8.5)	58 (5.6)

NaSDEK, Nationwide Survey on Dementia Epidemiology of Korea; SES, socioeconomic status All values are presented as the numbers with percentage in the parentheses. [a]The percentages in parentheses indicate the proportion of individuals aged 65 year or older weighted for sampling fraction and response rate and further age- and sex-standardized to the 2015 population structure using direct standardization. The distributions of 65–69 years of age group, sex, no formal education group (0 year), living area, and SES were significantly different between the NaSDEK 2008 and the NaSDEK 2017 ($p < 0.001$ for all cases by chi square tests). [b]Covered by the National Medicaid Program.

2017 (Table 2). These findings led to a decreased prevalence of VaD from 2.7% to 0.001% (odds ratio [95% CI], 0.04 [0.01–0.15], $p < 0.001$) over the same period for individuals aged below 75 years.

After the consecutive control for the remaining covariates under models 1 through 5 to show the robustness of the results above, we found that the decrease in the prevalence of VaD remained significant (Supplementary Tables 3 and 4). We observed that additional adjustment for SES explained 3 percentage points of the decline in the odds of VaD for the 70–74 years of age group between 2008 and 2017, and 2 percentage points of the decrease in the odds of VaD for women between the same period.

DISCUSSION

This study found that the prevalence of all-cause dementia, AD, and VaD in the Korean population aged 65 years or older showed a non-significant decrease between 2008 and 2017. However, the prevalence of VaD decreased significantly in the young-old population aged below 75 years and in women, though its sample size was rather small. The strength of our study is that it is the first to examine the trends in dementia prevalence of Asia using the identical study design and diagnostic procedures to a representative nationwide random sample of older adults across two surveys 9 years apart.

Many population-based epidemiologic studies have reported trends in the prevalence of all-cause dementia worldwide. Supplementary Table 5 summarizes the studies that compared the estimate at least 5 years apart. It reveals that the trend was not consistent even between high-income Western countries and varied considerably according to study methods. For example, in both Western and Asian countries, dementia prevalence was found to be decreasing or stable in the studies that made the diagnosis of dementia based on a certain level of cognitive impairment [1, 2, 20, 44, 45] while increasing or stable when based on a relative change [7, 8, 11, 45–47]. This was also the case when we looked at the studies on an old-old population separately (Supplementary Table 6). If dementia is diagnosed based on a specific degree of cognitive impairment instead of its relative change over time, the prevalence of dementia can be underestimated if the cognitive reserve of the target

Table 2
Comparison of the prevalence estimates between the NaSDEK 2008 and the NaSDEK 2017

	NaSDEK 2008			NaSDEK 2017			Comparison[d]
	n	Prevalence[a]		*n*	Prevalence[a]		
		Adjusted[b]	Standardized[c]		Adjusted[b]	Standardized[c]	
Dementia							
Sex							
Men	119	8.0 (6.3 – 9.6)	12.9 (9.8 – 16.1)	49	5.3 (3.2 – 7.4)	10.8 (3.1 – 18.5)	1.06 (0.46–2.46)
Women	232	9.9 (8.2 – 11.6)	11.8 (7.3 – 16.3)	113	10.6 (7.4 – 13.8)	9.2 (6.1 – 12.4)	0.80 (0.46–1.41)
Age (y)							
65 – 69	43	3.6 (2.5 – 4.8)	6.4 (3.8 – 9.1)	8	2.4 (0.5 – 4.3)	2.2 (0.3 – 4.1)	0.59 (0.23 – 1.50)
70 – 74	66	5.2 (3.8 – 6.6)	6.8 (4.3 – 9.2)	15	3.5 (1.3 – 5.7)	4.7 (0.8 – 8.7)	0.89 (0.31 – 2.52)
75 – 79	82	11.3 (8.1 – 14.6)	12.8 (8.5 – 17.0)	30	7.4 (3.4 – 11.3)	14.4 (1.8 – 27.0)	1.34 (0.52 – 3.50)
80 – 84	67	17.8 (11.6 – 24.0)	28.3 (10.3 – 46.4)	45	19.3 (9.9 – 28.7)	19.7 (9.8 – 29.5)	0.71 (0.28 – 1.78)
85 +	93	30.5 (22.1 – 38.9)	41.0 (27.7 – 54.3)	64	33.1 (20.9 – 45.3)	34.7 (19.8 – 49.6)	0.93 (0.38 – 2.28)
All	351	9.2 (7.9 – 10.4)	12.3 (9.3 – 15.2)	162	8.5 (6.5 – 10.5)	9.8 (6.3 – 13.3)	0.89 (0.54 – 1.48)
AD							
Sex							
Men	75	5.1 (3.8 – 6.3)	7.8 (5.5 – 10.1)	33	3.8 (2.1 – 5.6)	5.6 (1.9 – 9.3)	0.71 (0.32–1.55)
Women	177	7.3 (6.0 – 8.7)	7.5 (5.3 – 9.8)	88	8.2 (5.6 – 10.9)	7.4 (4.8 – 10.1)	1.06 (0.61–1.83)
Age (y)							
65 – 69	24	2.1 (1.2 – 3.0)	2.9 (1.3 – 4.5)	7	2.2 (0.3 – 4.1)	2.0 (0.2 – 3.8)	0.93 (0.34 – 2.50)
70 – 74	41	3.4 (2.2 – 4.5)	4.2 (2.6 – 5.9)	11	2.8 (0.8 – 4.8)	4.4 (0.5 – 8.3)	1.23 (0.39 – 3.86)
75 – 79	53	6.9 (4.7 – 9.1)	8.1 (5.0 – 11.2)	18	4.0 (1.6 – 6.3)	4.3 (1.1 – 7.4)	0.54 (0.22 – 1.31)
80 – 84	52	13.2 (8.3 – 18.1)	13.4 (5.8 – 21.0)	35	15.1 (7.0 – 23.1)	15.5 (6.7 – 24.3)	1.22 (0.46 – 3.20)
85 +	82	26.9 (19.2 – 34.7)	38.7 (25.4 – 52.1)	50	27.5 (16.8 – 38.3)	30.7 (16.6 – 44.9)	0.83 (0.33 – 2.08)
All	252	6.5 (5.5 – 7.5)	7.6 (6.0 – 9.3)	121	6.4 (4.8 – 8.1)	6.8 (4.6 – 8.9)	0.91 (0.58 – 1.42)
VaD							
Sex							
Men	38	2.5 (1.7 – 3.3)	4.5 (2.4 – 6.5)	12	0.9 (0.3 – 1.4)	4.3 (–2.5 – 11.2)	2.19 (0.45–10.61)
Women	43	2.1 (1.2 – 3.1)	1.9 (0.9 – 2.8)	11	0.7 (0.2 – 1.2)	0.5 (0.1 – 0.8)	**0.27 (0.10–0.72)[f]**
Age (y)							
65 – 69	15	1.2 (0.6 – 1.9)	3.0 (1.0 – 5.0)	0	-	-	-[e]
70 – 74	22	1.6 (0.9 – 2.3)	2.4 (0.6 – 4.1)	3	0.4 (0.0 – 0.9)	0.1 (0.0 – 0.2)	**0.07 (0.01 – 0.39)[f]**
75 – 79	23	3.7 (1.6 – 5.7)	3.9 (1.6 – 6.1)	7	1.3 (0.2 – 2.3)	7.1 (–4.8 – 18.9)	3.02 (0.51 –17.95)
80 – 84	10	3.5 (0.0 – 7.1)	2.9 (0.5 – 5.3)	4	0.7 (0.0 – 1.5)	1.6 (–0.8 – 4.0)	0.57 (0.10 – 3.18)
85+	11	3.6 (1.3 – 5.8)	2.2 (0.0 – 4.5)	9	0.3 (0.7 – 5.4)	3.0 (0.0 – 6.0)	1.81 (0.47 – 6.99)
All	81	2.3 (1.6 – 2.9)	2.9 (1.9 – 3.9)	23	0.8 (0.4 – 1.1)	1.9 (–0.7 – 4.6)	0.99 (0.27 – 3.55)
MCI							
Sex							
Men	209	20.1 (15.6 – 24.6)	26.4 (21.1 – 31.7)	46	20.2 (11.7 – 28.7)	31.3 (15.9 – 46.9)	1.49 (0.72–3.11)
Women	278	25.9 (21.7 – 30.1)	24.6 (19.9 – 29.2)	64	26.4 (17.5 – 35.3)	23.1 (14.2 – 32.1)	0.91 (0.51–1.63)
Age (y)							
65 – 69	138	20.1 (15.3 – 25.0)	26.4 (20.1 – 32.7)	16	13.8 (2.4 – 25.3)	15.7 (1.6 – 29.9)	0.47 (0.18 – 1.20)
70 – 74	169	21.6 (16.3 – 27.0)	25.5 (19.1 – 31.8)	26	20.9 (9.3 – 32.6)	35.3 (16.3 – 54.4)	1.77 (0.77 – 4.06)
75 – 79	96	25.3 (17.4 – 33.2)	23.1 (15.3 – 31.0)	25	22.8 (9.7 – 36.0)	23.1 (7.9 – 38.3)	0.98 (0.38 – 2.51)
80 – 84	48	28.9 (18.5 – 39.3)	23.1 (12.7 – 33.4)	30	47.2 (30.9 – 63.4)	38.8 (22.9 – 54.8)	2.24 (0.90 – 5.56)
85 +	45	35.6 (23.1 – 48.1)	30.2 (18.2 – 42.2)	13	27.8 (10.6 – 45.0)	20.4 (5.9 – 35.0)	0.49 (0.17 – 1.43)
All	487	23.7 (20.6 – 26.8)	25.3 (21.9 – 28.8)	110	24.0 (17.8 – 30.3)	26.2 (17.9 – 34.5)	1.08 (0.67 – 1.73)

NaSDEK, Nationwide Survey on Dementia Epidemiology of Korea; N, numbers of the individuals in the diagnostic phase; OR, odds ratio; CI, confidence intervals; AD, Alzheimer's disease; VaD, vascular dementia; MCI, mild cognitive impairment [a]Percent with 95% confidence intervals [b]Adjusted for sampling fraction and response rate at each of the phase I and II [c]Standardized to the population structure estimated by the Korean National Census 2015 [d]Odds ratios with 95% confidence intervals estimated by weighted logistic regression adjusting for age, sex, years of education, living area, and socioeconomic status compared to the prevalence estimates in the NaSDEK 2008 [e]Not applicable because none of the VaD case was identified in the diagnostic phase of the NaSDEK 2017 survey [f] $p < 0.01$.

population improves over the period between studies. Therefore, one needs to be cautious when interpreting the results of epidemiologic studies that define dementia based on a specific level of impairment in cognitive function.

There is an interplay between prevalence, incidence, and mortality. In Supplementary Table 7, we present that most of the population-based epidemiologic studies reported a decreasing incidence of all-cause dementia over the last two to three

decades, regardless of how they made the diagnosis. In countries where life expectancy and the mortality of dementia had not changed substantially such as US and Western European countries [44, 45, 48], this reduction in incidence may directly result in a decrease in its prevalence. However, in the high-income East Asian countries like Japan and Korea where life expectancy had dramatically increased [48], and the mortality of dementia had been decreasing [9], the reduction in its incidence cannot be simply translated into a reduction in its prevalence, but rather, a stable or increasing trend could be expected [9]. This trend was previously conceptualized by a synthetic review [49] as an Accelerated model. According to it, Japan in the period between the 1980s and early 2000s has an increase in the prevalence of dementia followed by a plateau at which point the non-significant decrease in the prevalence observed in Korea between 2008 and 2017 seemed to correspond and, eventually, it is expected that its prevalence might be decreased like seen in the high-income Western countries.

When we analyzed AD and VaD separately, the prevalence of VaD decreased in women and the young-old population under 75 years of age although the sample size of the latter group was relatively small. It had been known that the major risk factors for VaD include hypertension [50], diabetes [51], obesity [52], and atrial fibrillation [53]. Regarding these factors in Korea, recent studies suggested that a decline in the age-standardized prevalence of hypertension for individuals aged 30 years or older between 1998 and 2016 was prominent only for women [54], an increment in the age-standardized prevalence of fasting glucose $\geq$ 100 mg/dL for those aged 20 years or older between 2008 and 2013 was found only in men while that of women showed a nonsignificant change [55], and the age-standardized prevalence of obesity, defined as a body mass index $\geq$ 25 kg/m^2, among individuals aged 30 years or older between 2001 and 2013 increased for men but decreased for women [56]. Additionally, the annual prevalence of atrial fibrillation in Korea showed a relatively steady trend from 2008 through 2015 for those aged below 70 years, while it showed a steep increase for those aged 70 years or older over the same period [57]. We presumed that these trends of cardiovascular risk factors covering mid-life individuals could partly explain our results. A recent systematic review also proposed that increased cardiovascular risks were associated with a low level of health insurance in Korea [58], which might be the reason why SES was in part attributable to the decrease in the odds of VaD in our analyses.

The Chicago Health and Aging Project and the Medical Research Council - Cognitive Function and Ageing Study (MRC-CFAS) reported a non-significant decrease in the prevalence of MCI between 1993 and 2012 in the US [20] and between 1991 and 2011 in the UK, respectively [21]. The current study found a non-significant increase in the prevalence of MCI between 2008 and 2017. These results, incorporating the entire cognitive spectrum from MCI to dementia, have important implications for health care policymakers. If Korea will indeed follow the Accelerated model approaching the trend profile of high-income Western countries, it seems likely that the strategic plans for allocation of the health-care budget should consider the increasing proportion of individuals with MCI and the decreasing proportion of people with dementia. It is possible that preventive measures involving better education and favorable cardiovascular risk profiles in Korea need more attention to those with a high risk of developing MCI as well as dementia, compared to Western countries.

Our study has several limitations that warrant comments. First, there was a substantial decrease in the overall response rate of diagnostic phase II from 71.6% in the NaSDEK 2008 to 62.0% in the NaSDEK 2017, which might have resulted in a relative underestimation of dementia prevalence in the latter survey, as well as the violation of the randomization assumption for stratified random sampling [59]. However, we observed that the non-responders and the responders at phase II had comparable characteristics in both the NaSDEK 2008 and 2017 in terms of age, sex, years of education, and MMSE score (Supplementary Table 8). Second, we did not evaluate the burden of medical comorbidities such as hypertension and diabetes in both the NaSDEK 2008 and 2017, and thus could not adjust for comorbid medical conditions in the comparison of dementia prevalence between the two surveys, especially for the VaD. Third, we employed a diagnostic strategy that did not allow for 'mixed dementia' which has more than one etiology for the development of dementia. Instead, we put the AD in the highest position of the diagnostic hierarchy over other types of dementia that may lead to an overestimation of its prevalence. Nevertheless, our prevalence estimates of AD and VaD were within a reasonable range since they were comparable to those estimated from prior studies (5–7% for AD [60] and approximately 1.6% for VaD [61] among individuals

65 years or older). Fourth, because the absolute sample size of the young-old individuals with VaD in the 2017 survey was particularly small, the statistical results regarding this group should be cautiously interpreted.

In conclusion, Korea in the period between 2008 and 2017 showed a nonsignificant decrease in the prevalence of dementia. This might reflect the transition from the high incidence – low mortality to the low incidence – low mortality stage, approaching the trend profile of high-income Western countries.

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SUPPLEMENTARY MATERIAL

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