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Cognitive decline sensitivity by educational level and residential area

A descriptive study using long-term care insurance dementia registration data in South Korea

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Abstract

In South Korea Long-Term Care Insurance (LTCI) system, the special dementia rating (SDR) is a registration grading for dementia patients who do not have a physical disability or functional restrictions and is the first applicable registration following the diagnosis of dementia. We investigated the differences in age of registration of SDR and age of dementia diagnosis according to the educational level and residential area. This was a retrospective, cross-sectional study using the Korean National Health Insurance Service dataset. Applications for SDR between July 2014 and December 2016 were identified for participant selection, and 32,352 patients with dementia were included. Educational levels were defined as follows: the illiterate, only-reading, 1 to 6 years, 6 to 12 years, and ≥12 years. Urban residents were those who lived in the city, as ascertained from the Korean administrative district system. The primary outcomes were ages at the time of dementia diagnosis and SDR registration. A lower education level significantly correlated with a higher proportion of older adults, but a higher number of years of education significantly increased with the proportion of males and urban residents ($P < .001$ for all). A higher education level was inversely associated with the age at diagnosis of dementia ($P < .001$) and at the registration of SDR ($P < .001$). Urban residents were diagnosed with dementia at a significantly lower age and registered for SDR earlier than rural residents ($P < .001$ for both). Both urban and rural residents consistently showed that a higher educational level was associated with lower age at the dementia diagnosis and SDR registration. Patients who were highly educated and living in urban areas were diagnosed with dementia and registered on SDR when they were relatively younger, indicating that cognitive decline sensitivity and medical accessibility are related to earlier dementia diagnosis and registration.

Abbreviations: AD = Alzheimer disease, CDR = clinical dementia rating, GDS = global deterioration scale, ICD = international classification of disease, LTCI = long-term care insurance, MMSE = mini-mental state examination, NHIS = national health insurance service, OD = dementia of other conditions, SDR = special dementia rating, UD = unspecified dementia.

Keywords: dementia, long-term care insurance, national health program, neurocognitive disorders, public health

1. Introduction

South Korea is one of the countries with a rapidly aging population and, in 2017, became an "aged society" earlier than expected.[1] Aging is inevitably accompanied by an increased incidence of dementia, which is a degenerative brain disease. The National Institute for Dementia reported that, in 2019, Korea comprised more than 800,000 dementia patients, which is nearly 7.2% of the population aged 60 years or more,[2] and there would be more than 2000,000 dementia patients by 2050, which would impose a substantial socioeconomic burden on individuals and society.[3]

The Long-Term Care Insurance (LTCI) service in South Korea was launched in July 2008 to improve the quality of life of older adults and to reduce the burden they and their families incur from the increasing number of diseases that necessitate

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The data that support the findings of this study are available from a third party, but restrictions apply to the availability of these data, which were used under license for the current study, and so are not publicly available. Data are available from the authors upon reasonable request and with permission of the third party.

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long-term care in the aging population.[4] The social insurance system-based Korean LTCI for older adults was introduced as a system that is separate from the National Health Insurance Service (NHIS) system, and some are operated in the form of a public assistance service.[5] In the early phases of the LTCI, the beneficiaries were assigned 3 grades (LTCI rates 1–3) that were derived from 5 domains: physical ability, cognitive function, behavioral changes, demand for nursing, and rehabilitation.[6] However, this categorization excessively focused on the patient ability to move and perform daily activities and, therefore, only patients with limited physical ability or severe dementia could avail LTCI.[7] Compared with that in other countries that have advanced long-term care systems, the proportion of older dementia patients among the total LTCI beneficiaries in Korea was much smaller,[8] which engendered a need for greater health security for older dementia patients. In July 2014, the former LTCI rating system was restructured under rates 1 to 4 in the 5 abovementioned domains and an LTCI for dementia without physical disabilities, which constitutes a special dementia rating (SDR), was newly introduced as rate 5.[9] Thus, the scope of the LTCI was expanded to include patients with early dementia or dementia patients without physical disabilities or functional restrictions who were ineligible to avail benefits under the earlier LTCI rating system.[10,11] However, after the introduction of the SDR, large-scale studies on beneficiary characteristics and registration age have not been undertaken.

A higher education level is linked to higher cognitive reserve, and thus has a preventive effect on dementia.[12,13] Cognitive reserve is a concept that describes individuals with imaging- or histology-confirmed progressive dementia but without clinical cognitive decline.[14] It is unclear whether the cognitive reserve is related to the onset of dementia, although some studies have shown that cognitive reserve could not delay the onset of dementia or time of death.[15] Rather, a high cognitive reserve was associated with a faster rate of cognitive decline after the onset of dementia.[14,16] Based on previous reports of the association between educational level and dementia incidence, we inferred that a higher educational level was associated with a later dementia diagnosis and registration. Moreover, we hypothesized that urban residents would be diagnosed and registered with dementia faster because of better access to medical care.

In this study, we investigated the basic characteristics of dementia patients who were registered as SDR in the nationwide NHIS database to identify whether there are differences in the timing of registration of SDR and a dementia diagnosis according to the educational level and residential area.

2. Materials and methods

2.1. Data sources and approval of SDR

This retrospective observational study utilized a population-based dataset that was obtained from the NHIS (Research management number: NHIS-2018-20-008); the NHIS-National Health Information Database was used to extract the demographics, including sex, age, and residential area, of all participants and these data included comprehensive information about healthcare services. The study protocol was reviewed and approved by the Institutional Review Board of National Health Insurance Service Ilsan Hospital (NHIMC-2018-01-008), and the requirement of informed consent was waived due to the retrospective study design. This study was performed in compliance with the tenets underlying the Declaration of Helsinki.

The medical records containing a physician recommendation assigning an SDR between July 2014 and December 2016 were reviewed to identify potential participants. A total of 45,517 physicians' notes were reviewed, and 32,352 patients were included in the final analysis. We excluded patients who were: ineligible for an SDR; previously registered in the grading system due to brain lesions, intellectual disabilities, or mental disorders; were younger than 50 years; were co-diagnosed with diseases besides dementia that affect cognitive functions (based on the International Classification of Disease 10th Revision [ICD-10] codes: schizophrenia [F20], hemiplegia [G81], quadriplegia [G82], congenital brain disease [cerebral palsy, G80], encephalitis [A81–A89], mental retardation [F70–F79], and both pervasive and specific developmental disorders [F80–89]); and having a missing value (Fig. 1).

In South Korea, NHIS holders, their dependents, and medical-aid recipients are eligible for LTCI. Among these recipients, individuals aged 65 or more, or younger than 65 years but with diseases of senility, such as dementia, cerebrovascular

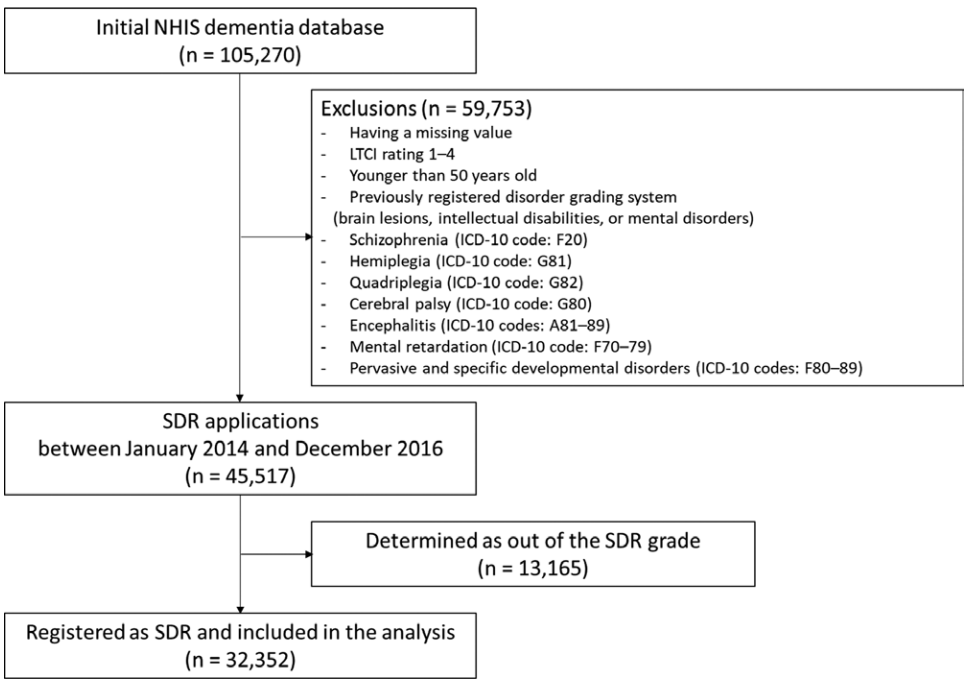

Figure 1. Flowchart of participant selection. LTCI = long-term care insurance, NHIS = national health insurance service, SDR = special dementia rating.

disease, Parkinson disease, and other diseases specified by the Presidential Decree, are the target beneficiaries. The process of LTCI registration is as follows. When a request for LTCI is received, a well-trained evaluation team of the National Health Insurance Corporation personally visits the applicant to investigate the essential aspects, including physical function, cognitive function, behavioral changes, need for nursing treatment, and exercise and joint motion restrictions, to calculate the approval scores. A physician review and opinion on LTCI are required for which the applicant visits the relevant medical institution and submits the certificate that is issued to the national health insurance corporation local office. Based on the physician opinion and the reports of the evaluation team, the final permission status and rate are assigned by the Long-Term Care Grade Judges' Committee (Fig. 2).[6,17]

The review and opinion document can only be issued by a physician who is certified as a dementia specialist by the Ministry of Health and Family Welfare[11] and contains an in-depth assessment report of cognitive function that includes the diagnostic code, the date of diagnosis of dementia, the treatment period, medications, the educational level of the patient, and findings of neurocognitive function tests, such as the Mini-Mental State Examination (MMSE), Global Deterioration Scale (GDS), and the clinical dementia rating (CDR). Additionally, if available, the Geriatric Depression Score, findings of other neurophysiological tests, or results of brain imaging study.

2.2. Variables

Based on the registration age at the time of application for the SDR, we divided the patients into 3 age groups: 50 to 60, 61 to 84, and ≥85 years. According to the type of dementia, we divided the study population into 4 groups: Alzheimer disease (AD; ICD-10 codes F00–F00.9), vascular dementia (ICD-10 codes F01–F01.9), dementia of other conditions (OD; ICD-10 codes F02–F02.8, and diseases such as Pick, Creutzfeldt-Jakob, Huntington, and Parkinson disease, and acquired immune deficiency syndrome), and unspecified dementia (UD; ICD-10 code F03). The MMSE, CDR, and GDS scores in the physician opinion document were collected as indicators of neurocognitive function. Based on the educational level, participants were divided into 5 groups: illiterate, who lacked formal education; only-reading, those who cannot write but read without formal education; 1 to 6 years, those who were educated at the elementary school level; 6 to 12 years, those who were educated at the middle to high school level; and ≥12 years, those who were educated at the university level or higher. For the stratification by residential area, urban residents were those who lived in the city according to the Korean administrative district system, and the other participants were classified as rural residents.

2.3. Statistical analysis

The participants' characteristics are expressed as the number (percentage) for categorical variables and mean ± standard deviation for continuous variables. To examine differences in covariates, the chi-square test for categorical variables and the One-Way ANOVA with Bonferroni multiple comparisons for continuous variables were used. All statistical analyses were performed using SAS ver. 9.4 (SAS Institute, Cary, NC). $P < .05$ was set as the indicator of statistical significance.

3. Results

3.1. Baseline characteristic of SDR beneficiaries according to their educational level

Baseline characteristics according to education level are summarized in Table 1. The proportion of older adults increased with lower educational levels ($P < .001$), whereas the male and urban residents' proportions significantly increased with a higher number of years of education ($P < .001$ for both). Among the dementia subtypes, the proportion of participants with AD was the highest in all educational groups. As the number of years of education increased, the proportions of vascular dementia and OD types tended to be relatively high whereas, conversely, the UD type showed a lower proportion ($P < .001$).

3.2. Neurocognitive functions according to educational levels

The MMSE at the time of application for the SDR in accordance with the educational levels showed that the educational level increased with the MMSE score, and there was a significant intergroup difference ($P < .001$). The CDR and GDS tended to decrease with the increase in the number of years of education. In the CDR, there was a significant difference only between the illiterate and those with 6 to 12 years of education ($P = .032$). With regard to the GDS, the illiterate group showed a significant difference with regard to all other groups, and the only-reading group showed a significant difference with regard to participants in the 6 to 12 and ≥12 years educational groups ($P < .001$; Table 2).

3.3. Difference in age at diagnosis of dementia and at registration of SDR

Supplementary Table 1, http://links.lww.com/MD/I497 summarizes the ages at the time of diagnosis of dementia and SDR registration according to educational level. A higher education level was associated with an earlier diagnosis of dementia ($P < .001$) and a quicker registration of the SDR ($P < .001$; Fig. 3A). The age difference at the time of dementia diagnosis was statistically significant, except in the comparison of the illiterate and only-reading groups and the 6 to 12 and ≥ 12 years of education groups. All age differences at the time of SDR registration were statistically significant except those in the comparison of the 6 to 12 and ≥ 12 years of education groups.

With regard to the residential area, we confirmed that urban residents were diagnosed with dementia at a significantly lower age and registered for SDR earlier than rural residents ($P < .001$ for both; Supplementary Table 2, http://links.lww.com/MD/I498). We performed subgroup analyses for each urban and rural resident; regardless of the residential area and identified a tendency wherein a higher educational level was associated with lower age at dementia diagnosis and SDR registration (Fig. 3B and C); ages at the time of dementia diagnosis and SDR registration for each urban and rural resident are shown in Supplementary Tables 3 and 4, http://links.lww.com/MD/I499.

4. Discussion

The primary finding of this study was that a higher educational level was associated with an earlier diagnosis of dementia and lower age at the time of SDR registration. This study is of great relevance as it is the first large-scale study using related data after the introduction of the SDR in the LTCI system of South Korea. We used SDR data in this study because it mainly targets patients with relatively early-stage dementia who show cognitive impairments but have little or no limitation of activities of daily living. Therefore, we considered SDR as the first nationwide registration system after the diagnosis of dementia that also has the advantage of high diagnostic accuracy because of the requirement to submit reviews and opinions by well-trained and certified physicians, based on radiological and neuropsychological examinations, for approval of the SDR application.

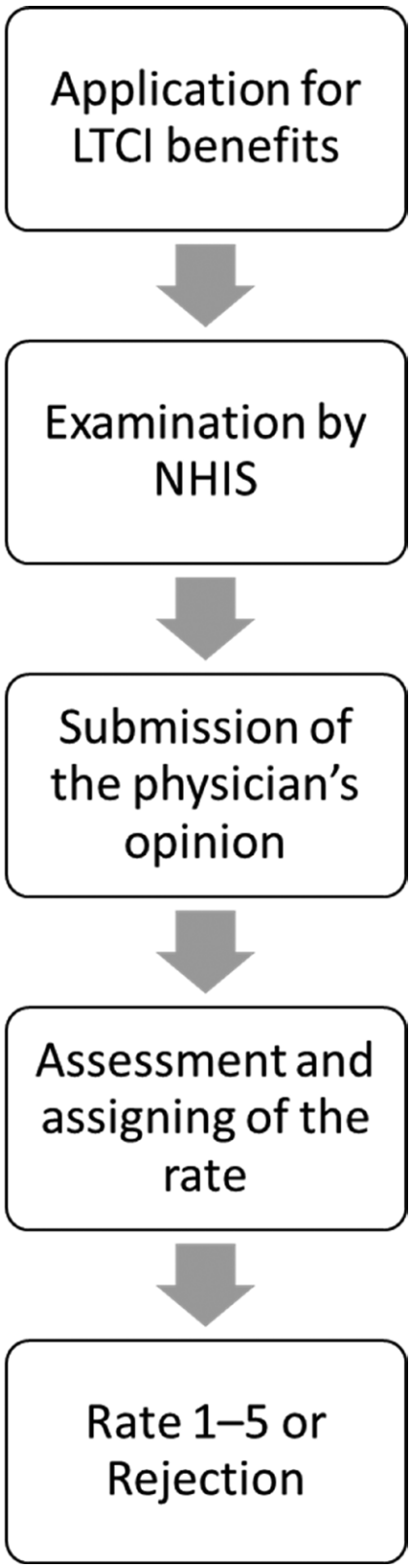

Figure 2. Procedure for LTCI coverage. LTCI = long-term care insurance, NHIS = national health insurance service.

Many demographic, physical, behavioral, and socioenvironmental factors, such as age, sex, genetic factors, physical activity, smoking, drug use, educational level, medical access, alcohol consumption, body mass index, and comorbidities are related to dementia.[18–21] Among these, investigations of the possible associations of the educational level and the degree of access to healthcare institutions of dementia patients have shown inconsistent results.[14,17,19,22] In the residential areas, urban residents were diagnosed and registered with dementia when relatively younger, which is consistent with our results. Contrastingly, for educational levels, our results showed the opposite effect to our assumption; it was confirmed that a higher educational level was associated with a lower age at diagnosis of dementia and registration for SDR.

We considered the following inferences for the results described above. First, we inferred that a higher-level of education conferred greater sensitivity to discover cognitive decline or abnormal behaviors that occurred after the onset of dementia. A study conducted in France by Amieva et al[16] reported that the first sign of cognitive decline was detected 15 to 16 years before being diagnosed with AD in the highly educated patient group, which is much earlier than the average 7 years in the low-education patient group. Our results confirmed that the higher the educational level, the higher is the neurocognitive function when applying for the SDR. This supports the fact that the initial inferences presented above—wherein patients and guardians sensitively identify early abnormalities of dementia—affected the time of SDR registration. Consequently, we can interpret that the higher the educational level, the higher is the sensitivity to cognitive decline. Another reason was that with a diminishing level of education, dementia patients might be ignorant of the LTCI benefits and delay their application. However, according to the subgroup analysis of urban and rural residents, we can infer that the difference in cognitive decline sensitivity by educational level would have had a greater effect on earlier dementia diagnosis and SDR registration.

The participants who were urban residents or had a high-level of education demonstrated an earlier diagnosis and registration of dementia, indicating that the national service entitlement rate is relatively high in this population group. Conversely, we confirmed that the age of dementia diagnosis and SDR registration was higher for patients living in rural areas and with low educational levels. Therefore, we could infer that the latter received relatively little benefits from the SDR. From this, we could indirectly infer that there were economic and geographical barriers to the diagnosis of dementia and the application for the SDR of LTCI.[23] In particular, to apply for the SDR, it is necessary to have access to advanced medical staff who are professionally trained and certified in the diagnosis of dementia, imaging findings such as magnetic resonance imaging-or computed tomography, and neuropsychological examination items. If there is a high-level hospital specializing in dementia in the area where the patient lives, it becomes easier to conduct such tests; thus, people living in large cities with large hospitals are diagnosed with dementia early. Therefore, we suggest a need for publicity, education, and agency services for LTCI applications to ensure that even people living in rural areas, where access to advanced medical institutions is difficult, or those with a low level of education, can equitably receive the benefits of LTCI. In addition, it is necessary to activate the medical delivery system for dementia diagnosis from the regional dementia centers or local clinics to higher-level hospitals after screening.

With regard to the demographic composition of this study, there was a difference in education level according to sex and age. This is presumably because older patients with dementia at the time of this study period represent the postwar generation, and the opportunity for education was relatively greater for men due to the characteristics of the times[17,24]; this was supported by the sharp decrease in the illiteracy rate among the relatively young patients who were 50 to 60 years old. South Korea has undergone rapid social change over the past few decades, and the generational characteristics are changing faster than in other countries. The new generation to be included in the older population in the future will have higher access to medical care than

Table 1

Baseline characteristic of the participants.

Characteristics	Educational levels					*P* value
	Illiterate (n = 7441)	Only-reading (n = 6907)	1–6 yrs (n = 10,417)	6–12 yrs (n = 5047)	≥2 yrs (n = 2540)	
Age group, yrs, n (%)						<.001
50–60	22 (0.3)	21 (0.3)	94 (0.9)	157 (3.1)	79 (3.1)	
61–84	5097 (68.5)	4835 (70.0)	8344 (80.1)	4113 (81.5)	2062 (81.2)	
≥85	2322 (31.2)	2051 (29.7)	1979 (19.0)	777 (15.4)	399 (15.7)	
Male, n (%)	528 (7.1)	960 (13.9)	2729 (26.2)	2407 (47.7)	1666 (65.6)	<.001
Urban residence, n (%)	3141 (42.2)	3547 (51.4)	6130 (58.8)	3436 (68.1)	1860 (73.2)	<.001
Dementia subtypes, n (%)						<.001
Alzheimer disease	5476 (73.6)	5118 (74.1)	7636 (73.3)	3639 (72.1)	1880 (74.0)	
Vascular dementia	618 (8.3)	642 (9.3)	1073 (10.3)	580 (11.5)	267 (10.5)	
Dementia of other diseases	112 (1.5)	118 (1.7)	229 (2.2)	136 (2.7)	96 (3.8)	
Unspecified dementia	1235 (16.6)	1029 (14.9)	1479 (14.2)	692 (13.7)	297 (11.7)	

Table 2

Neurocognitive functions at the time of SDR application according to the educational level.

	Educational levels					*P* value
	Illiterate	Only-reading	1–6 years	6–12 years	≥12 years	
MMSE, mean ± SD	11.36 ± 6.01	13.47 ± 5.23	15.11 ± 5.12	16.77 ± 5.66	18.15 ± 5.53	<.001
CDR, mean ± SD	1.92 ± 4.05	1.86 ± 5.13	1.79 ± 5.47	1.59 ± 4.26	1.69 ± 5.55	.032a
GDS, mean ± SD	4.79 ± 3.33	4.57 ± 3.28	4.45 ± 3.57	4.29 ± 2.54	4.29 ± 3.92	<.001b

[a] Significant only in the comparison between the illiterate group versus the ≥ 12-yrs education level group.

[b] Significant, except between the educational-levels groups of only-reading versus 1 to 6 yrs; 1 to 6 yrs versus 6 to 12 yrs; 1 to 6 yrs versus ≥12 yrs; and 6 to 12 yrs versus ≥12 yrs.

CDR = clinical dementia rating, GDS = global deterioration scale, MMSE = mini-mental state examination, SD = standard deviation, SDR = special dementia rating.

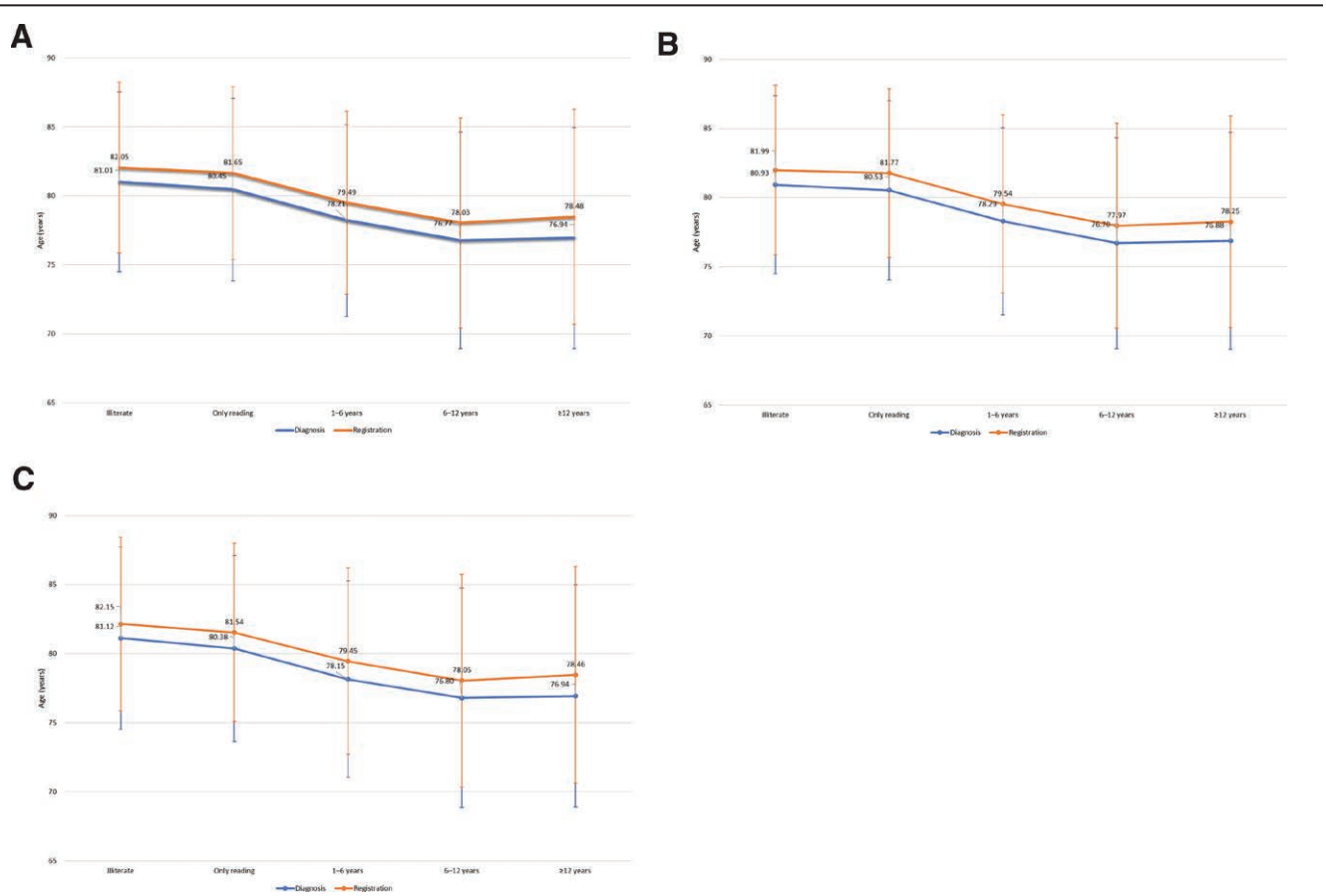

Figure 3. Age at dementia diagnosis and SDR registration according to the educational level. The higher the education level, the younger the patient at the dementia diagnosis and at SDR registration, except in the ≥12-yr educational level group. This trend is similar in the analysis of (A) all patients, (B) patients in urban areas, and (C) patients in rural areas. SDR = special dementia rating.

the previous generation, and as both men and women are given equal educational opportunities, it is expected that the characteristics of SDR beneficiaries will reflect these demographic and sociological changes.[25] In addition, this study analyzed the first 2 and a half years after the introduction of the SDR. In January 2018, the SDR was further subdivided, and a cognitive support rate was newly established whereby the scope has been further expanded and improved so that all dementia patients can be eligible for LTCI.[17] Therefore, further research is needed.

The limitations of this study are as follows. Although we provided descriptive results, the preventive effect of education on dementia in the entire population could not be verified because we did not present the odds ratio of dementia according to the educational levels. In addition, it is difficult to generalize the characteristics of all dementia patients, as the attributes of SDR mainly target early-stage dementia patients who do not have limitations in physical activity. Our data did not consider the patients' comorbidities; therefore, it was not possible to confirm the effect of comorbidities on the outcome. Finally, the input of an ambiguous diagnosis, such as unspecified type, could confer a potential bias.

In conclusion, this study demonstrated the age-related differences in the diagnosis of dementia and registration of SDR according to the educational level and residential area. Individuals with higher educational levels were highly sensitive to early changes of dementia. This study is important as this is the first nationwide large-scale report on the decline in cognitive sensitivity according to the educational level and residential areas ascertained from the Korean SDR data.

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Author contributions

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Investigation: Dougho Park, Han Eol Cho.
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Writing – original draft: Dougho Park, Chan Woong Jang.
Writing – review & editing: Dougho Park, Han Eol Cho, Jong Hun Kim, Hyoung Seop Kim.

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