The impact of the long-term care Cognitive Assistance Grade on health outcomes among older adults

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ABSTRACT

The impact of the long-term care Cognitive Assistance Grade on health outcomes among older adults

Background: With the global aging of the population, managing older adults' cognitive functions and alleviating the economic burden of dementia care have become critical challenges. In January 2018, South Korea introduced the Cognitive Assistance Grade (CAG) within its Long-Term Care Insurance Program to slow cognitive decline and improve health outcomes among older adults. This study evaluated the impact of the CAG policy on the cognitive and physical functions of patients with dementia.

Methods: This study utilized the National Health Insurance Service's National Health Information Database, including data on 6,265 individuals. A quasi-experimental design was employed to analyze national data spanning from January 2014 to June 2024. The case group included 4,099 individuals who received the CAG, while the control group included 2,166 individuals who were deemed ineligible. Propensity Score Matching (PSM) and Difference-in-Differences (DID) analyses were performed to compare the outcomes between the two groups. Cognitive and physical function scores (from 0 to 100) were used as dependent variables, with higher scores indicating greater functional impairments. Generalized Estimating Equations (GEE) and negative binomial regression models with a log-link function were employed to account for skewed data distributions and control for confounders.

Results: Before and after the implementation of the CAG policy, the mean cognitive function scores increased from 34.55 to 41.91 in the case group and from 25.88 to 35.63 in the control group. Similarly, physical function scores increased from 15.57 to 17.47 in the case group and from 17.11

to 19.66 in the control group. The DID analysis showed that the CAG significantly slowed cognitive decline among beneficiaries compared to non-beneficiaries ($\beta = -0.1564$, $\exp(\beta) = 0.8552$, $p < 0.0001$). However, no statistically significant differences were observed in physical function ($\beta = 0.0356$, $\exp(\beta) = 1.0362$, $p = 0.2313$).

Conclusions: The CAG effectively mitigated cognitive decline among patients with dementia, emphasizing its critical role in preventive dementia care. However, its limited impact on physical function underscores the need to incorporate physical activity and rehabilitation. These findings provided valuable evidence for expanding the CAG policy to ensure broader and more equitable access to dementia care programs and support tailored interventions to improve the outcomes for at-risk older adults.

Key words: Cognitive Assistance Grade, Dementia Policy Evaluation, Cognitive Decline Prevention, Aging Population

I. Introduction

1. Background

The United Nations projects that the proportion of the global population aged 65 and above will increase from 10% in 2022 to 16% by 2050, emphasizing the need for countries with rapidly aging populations to establish universal healthcare and long-term care systems, as well as to enhance the sustainability of their social security and pension systems [1]. Currently, over 55 million people worldwide are living with dementia, which ranks as the seventh leading cause of death globally. The increasing prevalence of dementia presents substantial challenges for overall population health and public health policies [2, 3] . In South Korea, 18.4% of the population is aged 65 years or older as of 2023, with an annual average growth rate recorded at 3.3% between 1970 and 2018—the fastest among member countries of the Organisation for Economic Co-operation and Development (OECD) [4]. This demographic shift has entailed a concurrent rise in dementia, with 10.38% of the older adult population diagnosed with dementia in 2023 and an average increase of 50,000 new cases annually [5].

In 2019, the global economic burden of dementia was estimated at $2.8 trillion, with projections suggesting that it will rise to $4.7 trillion by 2030 and to $16.9 trillion by 2050 [4, 6]. These staggering social and economic costs emphasize the need for systematic planning to manage dementia and provide support for affected patients and their families. The South Korean government has implemented a long-term care insurance (LTCI) system to provide care for older adults individuals who face difficulties in performing daily activities due to aging and/or dementia. In July

2014, the Grade 5 in the LTCI was expanded to include patients with dementia, enabling them to access services. However, this grading system had several limitations, as it primarily focused on physical function, thereby excluding older adults with mild dementia who retained their physical abilities from receiving benefits.

To address this limitation, the Cognitive Assistance Grade (CAG) was introduced to the LTCI in January 2018, allowing individuals with mild dementia to qualify for benefits regardless of their physical function [7, 8]. Beneficiaries of the CAG are eligible for various services, including cognitive improvement programs, day and night care, and in-home support, all of which are aimed at delaying the progression of dementia symptoms [9].

Given that dementia is a degenerative disease characterized by progressive cognitive decline, preserving and sustaining cognitive functions is of paramount importance. Current treatments for dementia include both pharmacological and non-pharmacological interventions. The limited efficacy of pharmacological treatments, which cannot fully prevent or cure dementia, underscores the importance of non-pharmacological approaches [10-12]. Non-pharmacological interventions like physical activity, cognitive training, and social engagement are crucial in preventing dementia onset and in delaying the progression from mild cognitive impairment (MCI) to dementia [11, 12]. Numerous studies have reported that cognitive training—a central component of non-pharmacological management—is effective in maintaining or improving cognitive function, enhancing abilities to perform daily activities independently, reducing depressive symptoms, and improving the overall quality of life among patients with dementia. Cognitive training programs therefore offer significant potential for preventing and managing dementia.

Despite the growing importance of dementia prevention and the evaluation of program efficacy, research systematically evaluating the impact of the CAG on cognitive improvement among individuals with mild dementia has remained limited. To address this gap, this study systematically

investigates the impact of the CAG on the maintenance of cognitive and physical functions among its beneficiaries. By empirically examining the effectiveness of dementia care policies, this study will establish evidence to inform and support the development and implementation of future strategies and policies for the management and prevention of dementia.

2. Study objectives

In January 2018, South Korea introduced the CAG within its LTCI system, extending coverage to additional patients with dementia. This study aims to evaluate changes in cognitive and physical functions before and after the CAG's implementation and assesses its impact on beneficiaries compared to non-beneficiaries. The objectives of this study are as follows:

(1) To evaluate the impact of the CAG on cognitive function among patients with dementia receiving cognitive support services compared to non-recipients.

(2) To evaluate the impact of the CAG on physical function among patients with dementia receiving cognitive support services compared to non-recipients.

II. Literature Review

1. Definition and characteristics of dementia

Dementia is a clinical syndrome characterized by a significant decline in cognitive functions caused by various factors and encompassing a wide array of symptoms that can arise from multiple underlying conditions. It impairs memory, reasoning, problem-solving, language, and judgment, hindering an individual's ability to perform daily activities independently [13].

The most common form of dementia, Alzheimer's disease (AD), accounts for 60–80% of all dementia cases. It typically begins with difficulty remembering recent events and gradually progresses to impair long-term memory and motor functions such as walking and speech and may even lead to personality changes as the condition advances [13, 14]. A family history of AD is a significant risk factor, with having a first-degree relative diagnosed with AD increasing one's own risk by 10–30%.

Another major type of dementia is vascular dementia, which is associated with strokes or problems with blood flow to the brain. Key risk factors include diabetes, hypertension, and hypercholesterolemia [15]. Vascular dementia often manifests as a sudden worsening of symptoms due to damage to specific areas of the brain and accounts for approximately 10% of all dementia cases [16].

Other common types of dementia include Lewy body, frontotemporal, and mixed dementia. Lewy body dementia (LBD) presents the additional challenges of motor and balance issues alongside memory loss. Patients with LBD may experience fluctuations in attention, excessive

daytime drowsiness, and hallucinations. Meanwhile, frontotemporal dementia primarily affects personality and behavior, often resulting in inappropriate actions or language difficulties. Mixed dementia, which is primarily observed in individuals over the age of 80, involves the comorbidity of multiple dementia types, such as AD and vascular dementia, which leads to a more rapid progression of symptoms.

Lastly, certain forms of dementia are caused by reversible conditions, such as medication side effects, vitamin deficiencies, or thyroid hormone imbalances. These reversible causes can and should be identified through medical evaluations, as symptoms may be alleviated or cured entirely if appropriately treated. Given these diverse causes and symptoms, dementia requires a tailored, comprehensive approach to its diagnosis, management, and treatment.

2. The costs of dementia

2.1. Aging population and dementia prevalence in Korea

As of 2024, South Korea has surpassed the 20% threshold of individuals aged 65 and above, officially entering a "super-aged" society [17]. South Korea's journey from an aging society to a super-aged society (14% to 20% of the population being 65 and older took only seven years, a remarkably shorter time compared to Austria (53 years), the United Kingdom (50 years), the United States (15 years), and Japan (10 years) [18]. As noted above, South Korea recorded the fastest aging rate among the 37 OECD member countries between 1970 and 2018, with an average annual growth rate of 3.3%.

In 2022, a total of 923,003 individuals aged 65 and above were diagnosed with dementia as their primary condition and were recorded as accessing at least one medical service (inpatient, outpatient, or pharmacy). This accounted for 10.2% of the older adult population. The Central Dementia Center has estimated the prevalence using epidemiological studies and census data. The data have shown a consistent increase of approximately 50,000 new cases per year, with 750,000 in 2018, 790,000 in 2019, 840,000 in 2020, 890,000 in 2021, and 940,000 in 2022 [5].

Globally, the direct costs of dementia care are projected to reach $2 trillion by 2030. When including indirect costs, such as wage losses for caregivers, the total expenses are expected to rise to $9.12 trillion by 2050 [19, 20]. According to the WHO's Global Dementia Observatory (GDO) project, the overall economic costs of dementia are strongly correlated with its severity. Annual costs are estimated at $16,000 for mild dementia, $27,000 for moderate dementia, and $36,000 for severe dementia. Approximately half of all these expenses are attributed to informal care, 34% are social welfare expenditures (e.g., long-term care facilities), and 16% are for direct medical services

like hospital stays [21, 22]. These figures highlight the critical need for early prevention and management to mitigate dementia-related costs. In South Korea alone, the annual national cost of dementia care was estimated at KRW 20.8 trillion in 2022, representing approximately 1% of the nation's GDP. Additionally, the annual per capita cost of dementia care accounted for 38.3% of an average household's annual income, which was calculated based on average monthly household income [5, 22].

The economic costs of dementia thus impose a significant challenge on healthcare systems worldwide. Given the rapid aging of South Korea's population and the increasing prevalence of dementia, there is an urgent need for strategic action plans to address the growing social and economic costs associated with dementia care and support.

3. Dementia management methods

3.1. Pharmacological approach

Pharmacological treatments for dementia primarily involve cholinesterase inhibitors and NMDA receptor antagonists. These medications can help maintain cognitive function and slow the progression of symptoms (Table 1). While they do not treat the underlying causes of dementia, they are effective in alleviating symptoms [23].

Table 1. Target populations for dementia medications by active ingredient

Category	Active ingredient	Target population
Cholinesterase Inhibitors	Donepezil	Mild to moderate Alzheimer's dementia
	Rivastigmine	
	Galantamine	
NMDA Receptor Antagonists	Memantine	Moderate to severe Alzheimer's dementia

Cholinesterase inhibitors are among the most commonly prescribed drugs for dementia, particularly for patients with mild to moderate AD [24]. Acetylcholine, a key neurotransmitter involved in memory and cognitive functions, becomes deficient due to the progressive degeneration of acetylcholine-producing cells in AD, leading to cognitive decline. Cholinesterase inhibitors work by inhibiting the enzyme cholinesterase, which prevents the breakdown of acetylcholine. This helps maintain acetylcholine levels, enhances neurotransmission between neurons, and improves cognitive functions.

The most common cholinesterase inhibitors include donepezil, rivastigmine, and galantamine. Donepezil, which was approved by the United States' Food and Drug Administration (FDA) in 1996,

is extensively utilized for treating mild to moderate AD. It typically starts at a dose of 5 mg and then titrated to 10 mg after 4–6 weeks, with a 23 mg formulation available for patients with moderate to severe dementia. Rivastigmine, approved by the FDA in 2000, is available as oral medication and as transdermal patches. The patch offers significant advantages for patients with poor medication adherence. Rivastigmine is prescribed for mild to moderate AD as well as dementia related to Parkinson's disease. Galantamine, approved by the FDA in 2001, is used for mild to moderate AD and is available in extended-release formulations, allowing for a single daily dose [25, 26].

The other category of medication, NMDA receptor antagonists, regulate excessive neuronal activity caused by glutamate, an excitatory amino acid, thereby reducing neuronal damage and slowing the progression of dementia. Memantine, the most common NMDA receptor antagonist, is generally prescribed for moderate to severe AD. Approved by the FDA in 2003, it can be administered as a monotherapy or along with cholinesterase inhibitors.

These medications generally exhibit comparable therapeutic effects and are selected based on the patient's condition and tolerance to side effects. However, they do not fundamentally halt the general progression of dementia, focusing instead on overall symptom relief and cognitive improvement [27].

In South Korea, the use of these medications for AD is regulated by reimbursement criteria under the national health insurance system, which requires patients to meet specific thresholds on assessments such as the Mini-Mental State Examination (MMSE) and dementia rating scales (e.g., the CDR or GDS) [27]. For example, donepezil is approved for mild to severe AD, while rivastigmine and galantamine are approved for mild to moderate AD as well as dementia resulting from Parkinson's disease (Table 2).

Table 2. Prescription and reimbursement criteria for medications

Medication	Target Population	Coverage
Donepezil (5–10 mg)	AD, VaD	MMSE≤26, CDR1-3, GDS 3−7
Donepezil (5–23 mg)		MMSE≤20, CDR2-3, GDS 4−7
Rivastigmine (capsule)	AD, AD with CVD, PDD	MMSE10-26, CDR1-2, GDS 3−5
Rivastigmine (patch)		MMSE≤26, CDR1-3, GDS 3−7
Galantamine	AD, AD with CVD	MMSE10-26, CDR1-2,GDS 3−5
Memantine	AD	MMSE≤20, CDR2-3, GDS 4−7
Memantine + AChE		

Source: Reconstructed from the Ministry of Food and Drug Safety's Integrated Drug Information System.

3.2. Non-pharmacological approach

The type and extent of dementia can indicate limitations in the availability of pharmacological treatments that are either capable of curing it or significantly delaying its progression [23]. Pharmacological treatments show highly variable outcomes depending on the patient and have been found to offer only limited long-term benefits [14]. In contrast, non-pharmacological management of dementia has gained attention as a critical therapeutic addition or alternative due to their cost-effectiveness, absence of side effects, and independence from medication prescriptions [13, 28, 29]. The primary objective of non-pharmacological (or behavioral) interventions is to enhance a patient's overall cognitive function or, at a minimum, to prevent its further decline, thereby enabling individuals to maintain their daily activities. These interventions can be categorized into four general types: holistic techniques, short-term psychotherapy, cognitive methods, and alternative strategies.

Holistic techniques comprehensively address the physical, emotional, and cognitive needs of patients with dementia. These include approaches such as cognitive stimulation and reality orientation therapy, which focus on preserving memory and functional abilities for daily life. Short-term psychotherapy is an intervention designed to rapidly and effectively foster emotional stability and alleviate stress, making it particularly effective in mitigating anxiety and depression, which can worsen dementia onset and symptoms.

Cognitive methods are designed to maintain and enhance patients' cognitive functions through techniques such as spaced retrieval and cognitive stimulation therapy. These methods continuously stimulate patients' cognitive processes with the aim of delaying functional decline [28]. They are also referred to as cognitive interventions and are broadly classified into cognitive stimulation, training, and rehabilitation. Cognitive stimulation involves the activation of various cognitive functions, such as recall and problem-solving, and is primarily applied in group settings to patients with MCI and early-stage dementia. Meanwhile, cognitive training focuses on specific cognitive functions, such as attention and memory, by providing individualized training programs. Finally, cognitive rehabilitation emphasizes improving the daily life and functions of patients with dementia, aiming for practical improvements to overall quality of life rather than solely maintaining cognitive functions [30].

Finally, alternative methods utilize a variety of sensory stimulation techniques. This can include music therapy, art therapy, and aromatherapy, all of which promote patients' emotional stability and physical health. These methods are especially effective for alleviating anxiety, stress, and emotional instability [31].

3.3. The importance and effectiveness of cognitive training

The diverse range of dementia symptoms that can be experienced by individuals necessitates personalized adjustments to accommodate each patient's cognitive abilities and specific needs [32]. In 2017, recognizing their safety and efficacy, South Korea's Ministry of Health and Welfare designated cognitive interventions as an innovative medical technology for enhancing cognitive function in patients with MCI as well as mild to moderate dementia [33].

Extensive research has underscored the significance and efficacy of cognitive training as a key component of non-pharmacological dementia management. Non-pharmacological interventions have been found to play a significant role in maintaining cognitive function and alleviating behavioral symptoms [34, 35] Cognitive training, sensory stimulation, and psychosocial interventions were reported to significantly improve the quality of life for both patients and their caregivers. Other studies have proven that pharmacological treatments alone cannot fully slow the progression of dementia, emphasizing the potential benefits of non-pharmacological approaches, including cognitive training [23]. Patients participating in cognitive stimulation programs have exhibited noticeable improvements in attention, memory, and executive function, alongside enhanced connectivity within their neural networks [36]. These findings suggest that cognitive training can induce meaningful change not only in daily dementia management but also at the deeper neurological level.

Cognitive training, in its various forms, has been demonstrated to improve overall cognitive function, enhance patients' abilities to perform daily activities independently, alleviate their depressive symptoms, and improve their overall quality of life. These non-pharmacological interventions go beyond mere symptom management, establishing themselves as pivotal strategies

for comprehensive dementia prevention and care. Given these benefits, cognitive training has become increasingly recognized as a cornerstone of effective dementia management (Table 3).

Table3. Previous studies about non-pharmacological interventions for dementia

Author	Title	Source	Summary of Results
Cammisuli, et al.	The Multidisciplinary Approach to Alzheimer's Disease and Dementia. A Narrative Review of Non-Pharmacological Treatment	Front Neurol. 2018 Dec 13;9:1058.	Highlighted that non-pharmacological treatments play a crucial role in maintaining cognitive function and alleviating behavioral symptoms. Reported that cognitive training, sensory stimulation, and psychosocial interventions improve patients' conditions and enhance the quality of life for both patients and caregivers.
Guzzon A, et al.	The Value of Supportive Care: A Systematic Review of Cost-Effectiveness of Non-Pharmacological Interventions for Dementia	PLoS One. 2023 May 12;18(5):e0285305.	Reported that non-pharmacological interventions, such as psychological therapies and personalized care, effectively improve patients' cognitive and emotional states while reducing caregiver burden.
Berg-Weger M	Non-Pharmacologic Interventions for Persons with Dementia	Mo Med. 2017 Mar-Apr;114(2):116-119.	Emphasized the lack of pharmacological treatments that can "cure" dementia or significantly slow memory and functional decline, while describing the importance of non-pharmacological interventions.
Samo Ribarič	Physical Exercise, a Potential Non-Pharmacological Intervention for Attenuating Neuroinflammation and Cognitive Decline in Alzheimer's Disease Patients	International Journal of Molecular Sciences, 2022, 23(6), 3245.	Highlighted physical exercise (PE) as an effective non-pharmacological strategy to mitigate cognitive decline in Alzheimer's disease patients.
Behfar Q, et al.	Improved connectivity and cognition due to cognitive stimulation in Alzheimer's disease	Frontiers in Aging Neuroscience, 2023 Aug 17;15:1140975.	Patients who participated in cognitive stimulation programs showed enhanced neural connectivity, which was associated with improved cognitive abilities. Significant improvements were also observed in memory, attention, and executive functions after cognitive training.
Ahn Myung-Sook & Cho Hyun-Sook	The Effects of Integrated Dementia Management Programs for Mild Dementia Patients in Long-Term Care Facilities	Journal of Korean Community Nursing, 30(4), 550-559.	Reported improvements in self-efficacy and cognitive function in mild dementia patients who received integrated dementia management programs.
Kim, et al.	The Effect of Computer-Based Cognitive Training Program on Cognition	Dement Neurocogn Disord. 2013 Dec;12(4):87-93.	Found that computer-based cognitive training programs significantly improved overall cognitive function in both mild cognitive impairment (MCI) and dementia patients, with greater effects observed in MCI patients.

4. Approaches to dementia management across countries

4.1. Dementia policies and programs in major countries

1) The United States

(1) UCLA Alzheimer's and Dementia Care Program

The University of California in Los Angeles (UCLA) has established an integrated program for patients with AD and dementia, adopting a multidisciplinary approach to diagnosis, treatment, and support. This program emphasizes the comprehensive evaluation of patients' health conditions and the development of personalized care plans tailored to the unique needs of both patients and their families [37]. Care managers are central to this program, as they ensure that treatment plans are aligned with the specific needs of patients and their families. The care managers also play a pivotal role in coordinating healthcare providers and connecting patients with community resources, enhancing both the accessibility and the effectiveness of care [38].

(2) Care Ecosystem

The Care Ecosystem, developed by the University of California in San Francisco (UCSF), is a remote-based support program designed to facilitate seamless access to essential information and resources for dementia patients and their families. This program employs care team navigators, who provide personalized support to patients and their families while maintaining continuous communication with medical professionals to closely monitor patients' health conditions. The Care Ecosystem emphasizes the strengthening of home-based care, enabling patients to remain in their homes for extensive periods. This approach not only enhances patients' quality of life but also provides critical support to families for effectively managing long-term care needs [39].

(3) Indiana University's Aging Brain Care Program

The Aging Brain Care Program, operated by Indiana University, offers a comprehensive care model for patients with dementia and other cognitive impairments. Utilizing a multidisciplinary team of nurses, social workers, and physicians, the program aims to enhance the quality of life for patients and their families through personalized, patient-centered care. This program focuses on optimizing healthcare system efficiency by integrating home-based care with outpatient medical resources. It not only enhances care delivery but also facilitates the sustainable management of healthcare resources [38].

2) Germany

Germany has widely implemented nurse-led, home-based dementia care programs, focusing on helping patients with dementia live independently within their homes. Nurses conduct regular home visits to assess patients' health status and provide necessary nursing and care services [40, 41]. This approach plays a pivotal role within Germany's long-term care insurance system, which significantly alleviates the economic and psychological strain on patients and their families.

3) The United Kingdom

The United Kingdom has been implementing the National Dementia Strategy since 2009, which focuses on the early diagnosis and systematic management of dementia. This strategy focuses on creating dementia-friendly communities that ensure that patients can live safely within their local communities while benefiting from various support programs. It also emphasizes raising the overall awareness of dementia and providing education for patients and their families [42, 43].

4) China

Shanghai has been recognized for its innovative approach in developing a community-based, integrated model of dementia care. This system facilitates early diagnosis and continuous management through collaboration between major hospitals and community health centers. The program leverages local resources to help patients remain at home for as long as possible [44]. Shanghai's model enhances the quality of life for patients and their families by strengthening psychological and emotional support systems. It is regarded as a significant initiative to address China's rapidly aging population and the increasing prevalence of dementia.

5. Long-Term Care Insurance and Cognitive Assistance Grade in Korea

5.1. Long-Term Care Insurance (LTCI)

LTCI, which was implemented on July 1, 2008, provides long-term care benefits to support the physical and household activities of older adults who may be unable to perform daily tasks independently due to advanced age or geriatric diseases. The primary objectives of LTCI are to promote their stability of health and living and alleviate the strain on their families [8].

LTCI covers elderly individuals aged 65 and above, as well as those under 65 who have been diagnosed with early-onset geriatric diseases like dementia or cerebrovascular disease. By law, all health insurance enrollees are automatically enrolled in LTCI, which, like health insurance, is therefore mandatory [45]. Additionally, the recipients of medical benefits under public assistance programs are excluded from health and long-term care insurance enrollment but are still covered by LTCI, which is paid for by both national and local governments [46].To receive the benefits of LTCI, an individual must be certified for long-term care, which grants the right to receive long-term care benefits. Long-term care accreditation involves assessing the patient's physical and mental condition. Based on the results of the accreditation survey, which is conducted by the public corporation, the recipient's physical and mental abilities are converted into a score (Table 4).

Table4. Long-term care insurance accreditation score survey items

Area	Items				
Physical Function (12 items)	·Dressing and undressing	·Washing face	·Brushing teeth		
	·Eating	·Bathing	·Changing positions		
	·Sitting up	·Transferring between seats	·Exiting the room		
	·Using the toilet	·Controlling bowel movements	·Controlling urination		
Cognitive Function (7 items)	·Short-term memory impairment	·Inability to follow instructions			
	·Disorientation to date	·Impaired situational judgment			
	·Disorientation to location	·Communication and delivery impairment			
	·Disorientation to age and date of birth				
Behavioral Changes (14 items)	·Delusions	·Wandering, restlessness	·Damaging objects		
	·Hallucinations, auditory hallucinations	·Getting lost	·Hiding money or objects		
	·Feeling sad, crying	·Verbal abuse, threatening behavior	·Wearing inappropriate clothing		
	·Irregular sleep patterns, day-night confusion	·Attempting to leave the house	·Inappropriate defecation/urination		
	·Resisting assistance	·Meaningless or inappropriate actions			
Nursing Care (9 items)	·Tracheostomy care	·Enteral feeding	·Catheter management		
	·Suctioning	·Pressure ulcer care	·Stoma care		
	·Oxygen therapy	·Cancer pain management	·Dialysis care		
Rehabilitation (10 items)	**Movement Disorders (4 items)**		**Joint Limitations (6 items)**		
	·Right upper limb	·Right lower limb	·Shoulder joint	·Elbow joint	·Wrist and finger joints
	·Left upper limb	·Left lower limb	·Hip joint	·Knee joint	·Ankle joint

Source: Notification on criteria for long-term care grading, 2018.

The resulting score determines categorization into Grades 1–5 or the CAG, reflecting the level of assistance required for daily life. A higher score indicates a greater need for support, corresponding to a higher grade level (Table 5).

Table5. Criteria for determining long-term care recognition ratings

Certification Grade	Condition	Score
Grade 1	Individuals requiring full assistance from others in daily living due to physical and mental disabilities.	95 points or more
Grade 2	Individuals requiring substantial assistance from others in daily living due to physical and mental disabilities.	75 points to less than 95 points
Grade 3	Individuals requiring partial assistance from others in daily living due to physical and mental disabilities.	60 points to less than 75 points
Grade 4	Individuals requiring some assistance from others in daily living due to physical and mental disabilities.	51 points to less than 60 points
Grade 5	Patients with dementia (limited to older adult diseases specified under Article 2 of the Enforcement Decree of the Long-Term Care Insurance Act).	45 points to less than 51 points
Cognitive Assistance Grade	Patients with dementia (limited to older adult diseases specified under Article 2 of the Enforcement Decree of the Long-Term Care Insurance Act).	Less than 45 points

Source: Notification on criteria for long-term care grading, 2018.

Long-term care benefits are categorized into in-home, institutional, and special cash benefits (Table 6). In-home benefits include day and night care, visiting care, bathing and nursing services, and short-term care services, all of which are provided at the recipient's home. Institutional benefits are delivered within older adult care facilities or community living homes and focus on providing education and training to improve the physical and mental functions of the residents. The special cash benefit compensates the costs of visiting care services provided by family members to individuals who face difficulties accessing other care services, such as those living in remote areas [47].

Table6. Types of long-term care insurance benefits

Long-Term Care Benefits	Type	Details
In-Home Benefits	Day/Night Care	Provides protection, education, and training for beneficiaries at long-term care institutions during specific hours of the day.
	Home Nursing	Nurses, dental hygienists, and nursing assistants (as long-term care providers) visit beneficiaries' homes or other locations as per a physician's instructions to provide nursing care and counseling.
	Home Care	Long-term care providers visit the beneficiaries' homes to assist with physical activities and household tasks.
	Home Bathing	Long-term care providers visit beneficiaries' homes using bathing equipment to provide bathing services.
	Short-Term Respite Care	Offers temporary protection, education, and training for beneficiaries at long-term care institutions for a specified period.
	Assistive Devices	Provides or rents devices that support daily living or physical activities. The items are designated by the Minister of Health and Welfare.
Institutional Care Benefits	Elderly Care Facilities	Provides education and training to beneficiaries residing in care facilities. ※Admission requirement: Minimum capacity of 10 residents.
	Elderly Homes Shared Living Homes	Offers education and training in a home-like residential setting for beneficiaries. ※Admission requirement: Capacity of 5–9 residents.
Special Cash Benefits	Family care financial support	Provides compensation equivalent to home care services when beneficiaries living in remote areas or under specific circumstances (e.g., natural disasters) receive home care from family members.

LTCI also provides a sliding scale of services based on the recipient's overall condition, with monthly caps set accordingly. The monthly cap is also categorized from Grade 1 to the CAG, with the higher levels providing more extensive support (Table 7).

Table7. Monthly benefit limits by long-term care grade

Grade	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Cognitive Assistance Grade
Monthly Limit (KRW)	2,069,900	1,869,600	1,455,800	1,341,800	1,151,600	643,700

5.2. Introduction of the Cognitive Assistance Grade

The CAG was introduced in January 2018 and focuses specifically on older adults with mild dementia. The program was created to help older adults individuals maintain independent living activities and prevent the progression of dementia [48]. The previous long-term care grading system classified recipients into Grades 1–5 based on physical function, which excluded individuals with mild dementia who retained good physical abilities, restricting their access to care services. Although the system was expanded in 2014 to include patients with dementia in Grade 5, thereby granting them access to long-term care services, some individuals with mild dementia still remained ineligible. To address this limitation, the CAG was established in 2018, enabling individuals with mild dementia to access long-term care services regardless of their physical function (Figure 1).

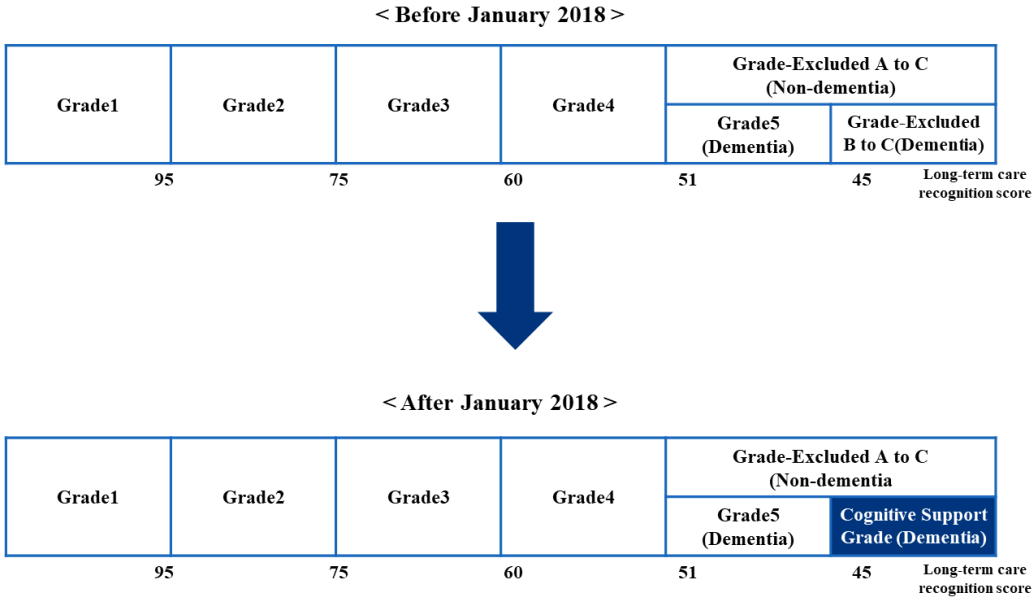

Figure1. Changes to the long-term care insurance grading system

The programs in the CAG focus on cognitively stimulating activities, such as memory enhancement, concentration improvement, and executive function training, helping individuals retain as much of their residual functions as possible and preventing further cognitive decline. The program must be delivered by a dementia care professional or program manager who has undergone specialized training, and it must last at least 60 minutes (Table 8). If these criteria are not met, the program will not be eligible for reimbursement [8, 48].

Table8. Composition of cognitive activity programs

Category	Examples
Exercise Programs	"Guidelines for Long-Term Care Insurance Health Improvement Programs," Physical and Cognitive Function Enhancement Program
Orientation (Reality Education)	"Daily Check-In Together"
Reminiscence Therapy	"Let's Share Memories Together"
Concentration	Finding hidden pictures, finding the same numbers, finding differences, connecting dots
Constructive Ability	Filling shapes, stacking blocks
Memory (Short-Term)	Answering questions after reading, memorizing shopping lists, recalling names, delayed recall training
Problem-Solving Ability	Performing calculations, solving proverbs
Activity Therapy	"Guidelines for Long-Term Care Insurance Health Improvement Programs," Physical and Cognitive Function Enhancement Program

Source: Cognitive activity tools by the National Health Insurance Service manual for program managers

Moreover, recipients of CAG services can receive an additional 30% of their monthly assistance cap if they utilize dementia-specific day or night care facilities for more than nine days per month. This system allows individuals with dementia to exceed their home benefit limit for necessary care and treatment, thereby alleviating the expenditures of families responsible for caregiving. Dementia-specific day and night care facilities are designed to provide tailored services

for individuals with dementia. These facilities strengthen the infrastructure for long-term care and are staffed by professionally trained dementia care managers. They offer group programs like reality orientation training (e.g., personal information and memory training), exercise therapy, family education and engagement programs, cognitively stimulating activities, and music therapy.

Recipients of CAG services are also eligible for up to eight days of short-term care services per year through the Dementia Family Leave Scheme, regardless of the monthly cap. Additionally, they can purchase or rent equipment to support their physical activities, within a limit of KRW 1.6 million per year.

6.3. Operation of long-term care insurance for the elderly

Since its introduction in 2008, the number of applicants and approved beneficiaries of LTCI has steadily increased each year. By 2022, the total number of applicants reached approximately 1.16 million, with about 1.02 million individuals qualifying for LTCI benefits [49]. This upward trend, observed consistently, underscores the growing need and demand for long-term care services each year (Table 9).

Table9. Status of long-term care grade determination

Category		Total Population	Beneficiaries							Non-Eligible Individuals			
			Subtotal	Grade 1	Grade 2	Grade 3	Grade 4	Grade 5	Cognitive Assistance Grade	Subtotal	Grade-Excluded A	Grade-Excluded B	Grade-Excluded C
2022	Count	1,160,850	1,019,130	49,946	94,233	278,520	459,316	113,842	23,273	141,720	74,878	50,385	16,457
	Proportion (%)	100.00	87.80	4.30	8.10	24.00	39.60	9.80	2.00	12.20	6.50	4.30	1.40
2021	Count	1,097,462	953,511	47,800	92,461	261,047	423,595	106,107	22,501	143,951	74,838	53,700	15,413
	Proportion (%)	100.00	86.90	4.40	8.40	23.80	38.60	9.70	2.10	13.10	6.80	4.90	1.40
2020	Count	1,007,423	857,984	43,040	86,998	238,697	378,126	91,960	19,163	149,439	76,481	58,659	14,299
	Proportion (%)	100.00	85.20	4.30	8.60	23.70	37.50	9.10	1.90	14.80	7.60	5.80	1.40
2019	Count	929,003	772,206	44,504	86,678	226,182	325,901	73,294	15,647	156,797	78,462	64,927	13,408
	Proportion (%)	100.00	83.10	4.80	9.30	24.30	35.10	7.90	1.70	16.90	8.40	7.00	1.40
2018	Count	831,512	670,810	45,111	84,751	211,098	264,681	53,898	11,271	160,702	77,779	69,529	13,394
	Proportion (%)	100.00	80.70	5.40	10.20	25.40	31.80	6.50	1.40	19.30	9.40	8.40	1.60
2017	Count	749,809	585,287	43,382	79,853	196,167	223,884	42,001	-	164,522	77,244	72,491	14,787
	Proportion (%)	100.00	78.10	5.80	10.60	26.20	29.90	5.60		21.90	10.30	9.70	2.00
2016	Count	681,006	519,850	40,917	74,334	185,800	188,888	29,911	-	161,156	78,048	68,715	14,393
	Proportion (%)	100.00	76.30	6.00	10.90	27.30	27.70	4.40		23.70	11.50	10.10	2.10

Source: National health service management disclosure restatement.

By 2022, 23,273 individuals had received LTCI services under the CAG. While the number of beneficiaries under the CAG has increased annually, the number of individuals classified as “non-assessed” has steadily decreased (Figure 2). This trend likely reflects improved access to long-term care services and the expansion of institutional support mechanisms, such as the addition of the CAG, which have enabled more people to benefit from these services.

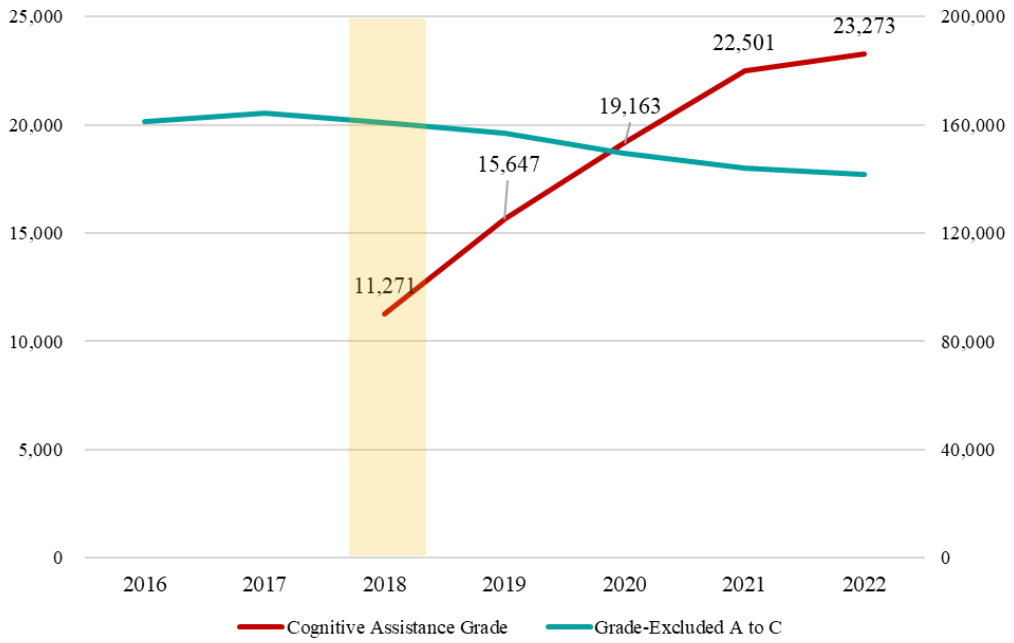

Figure2. Trends in Cognitive Assistance Grade and Grade-Excluded

The proportion of LTCI recipients among the population with dementia steadily increased from 37.3% in 2015 to 50.6% in 2020 (Figure 3). This growth demonstrates the expanding role of LTCI in dementia management. Notably, the number of LTCI recipients among patients with dementia nearly doubled since 2015, rising from approximately 183,000 in 2015 to 366,000 in 2020, highlighting the increasing demand for long-term care services for people with dementia [5, 50].

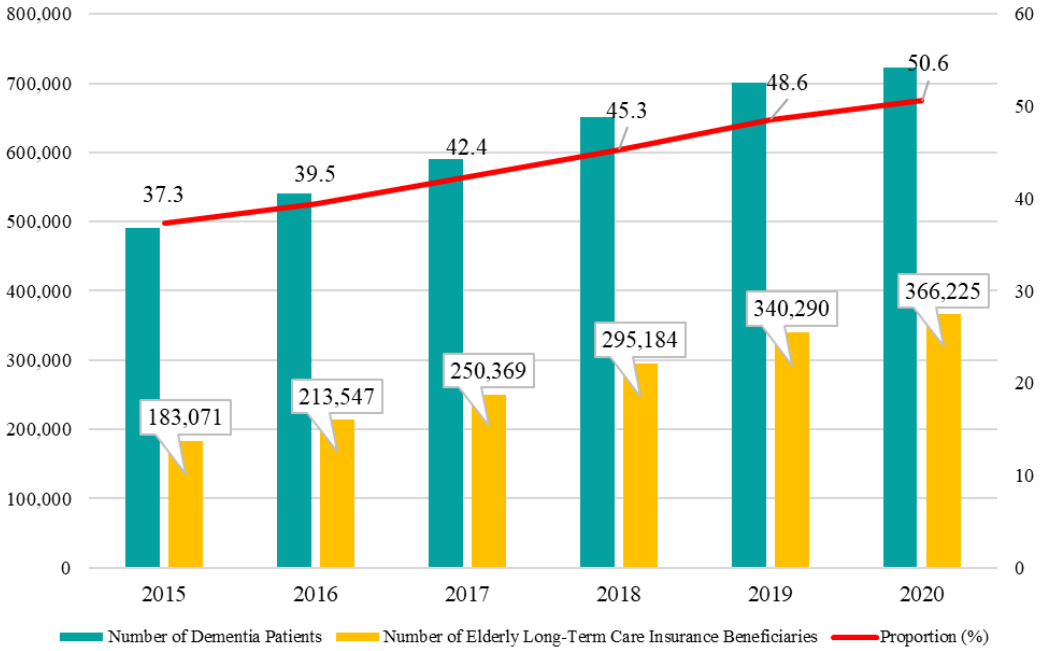

Figure3. Changes in the proportion of long-term care insurance beneficiaries among dementia patients

III. Material and Methods

1. Study population and design

1.1. Data source

This study utilized a database provided by the National Health Insurance Service (NHIS), encompassing data from 2014 to 2024. To analyze the impact of the introduction of the CAG on health outcomes of older adults with dementia, a database was constructed comprising 106,808 individuals who were granted the CAG between January 2018 and June 2024, alongside a 25% random sample of individuals who were aged 57–80 years as of 2014. The database integrated the NHIS and LTCI datasets, which were derived from claims submitted by healthcare institutions and long-term care providers, thus encompassing all healthcare utilization records covered by insurance benefits. The NHIS database contains a wide range of information on the eligibility criteria for both health insurance enrollees and medical aid beneficiaries, allowing for a comprehensive analysis of patterns in healthcare utilization. This includes demographic data (e.g., gender, age, subscriber type, income level, disability status, and mortality information), as well as details of healthcare service claims. In addition, the LTCI database provides information on the eligibility assessments of long-term care applicants, records of service utilization, and data on the institutions providing these services.

1.2. Study population

This study analyzed the impact of the CAG on health outcomes in older adult individuals with dementia who applied for long-term care services. For the Difference-in-Differences (DID) analysis, participants were divided into a CAG beneficiary case group and a non-beneficiary control group. The index month separating the pre- and post-intervention periods was defined as the month when the CAG was granted to individuals in the case group. The 24 months prior to the index month were designated as the pre-intervention period, whereas the 24 months following the index month were designated as the post-intervention period. Participants with observed data for both pre- and post-intervention periods were included in the analysis.

The case group consisted exclusively of individuals who had been excluded from LCTI before obtaining the CAG designation. The control group included individuals who were consistently determined as grade-excluded for both the pre- and post-intervention periods and did not benefit from the CAG. After defining the study population, 1:1 Propensity Score Matching (PSM) was applied to minimize the confounding variables between the case and control groups. This method minimized the baseline differences between the groups, enhancing the reliability of the DID analysis. The index date for the control participants was defined based on the index date of the matched case participants. This ensured that the control participants were assigned the same intervention timing as their matched case group. The detailed process of participant selection is presented in Figure 4.

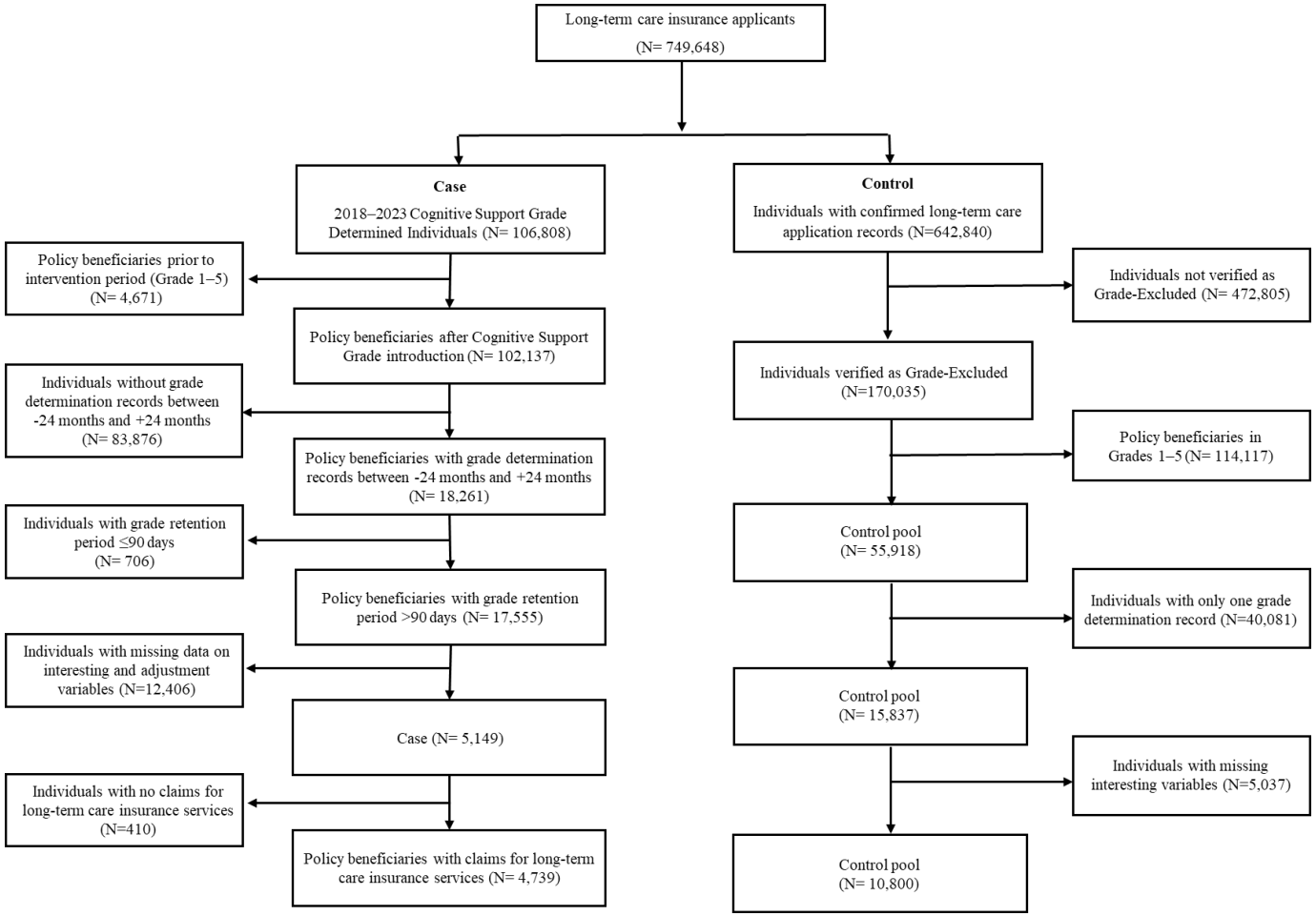

Figure4. Flow chart of study population for cognitive and physical function analysis

The case group initially included 106,808 individuals who received the CAG designation between 2018 and 2023. Individuals identified as policy beneficiaries with Grades 1–5 during the pre-intervention period (N = 4,671) were excluded from the analysis. Additional exclusions were applied to individuals with no grade determination records within 24 months before (pre-intervention) and after (post-intervention) the date of their CAG determination (N = 83,876). Those whose CAG determination had lasted 90 days or less (N = 706), as well as those with missing values in key variables and covariates (N = 12,406), were also excluded. Finally, individuals who did not utilize CAG benefits and had no claims for LTCI services (N=410) were excluded. After applying the above criteria, the final case group comprised 4,739 participants.

The control group was selected from individuals with records of long-term care applications and initially included 642,840 individuals. Among them, 170,035 non-beneficiaries who had been classified as grade-excluded were included. Policy beneficiaries who were classified as Grades 1–5 during the pre-intervention period (N = 114,117) were excluded. Further exclusions were made of individuals with only one grade determination record (N = 40,081) and those with missing values in key variables and covariates (N = 5,037). Following these steps, the final control group consisted of 10,800 participants.

To select a control group with similar characteristics to the case group, 1:1 PSM was performed, matching control group participants who were determined to be grade-excluded in the same quarter as the first date of CAG determination of the case group. Gender and cognitive function scores were used to calculate propensity scores to ensure homogeneity between the case and control groups (Figure 5). The grade determination date, defined as the intervention point for both the CAG and the grade-excluded cases, served as the reference point for accessing variables and aligning timeframes during the matching process. Based on this, the 24 months prior to the intervention point were designated as the pre-intervention period and the 24 months following it as the post-intervention

period. As a result of the matching process, 4,099 participants were matched in the case and control groups. Subsequently, the control group participants without observations for both the pre- and post-intervention periods were excluded. This resulted in a final sample of 4,099 participants in the case group and 2,166 participants in the control group.

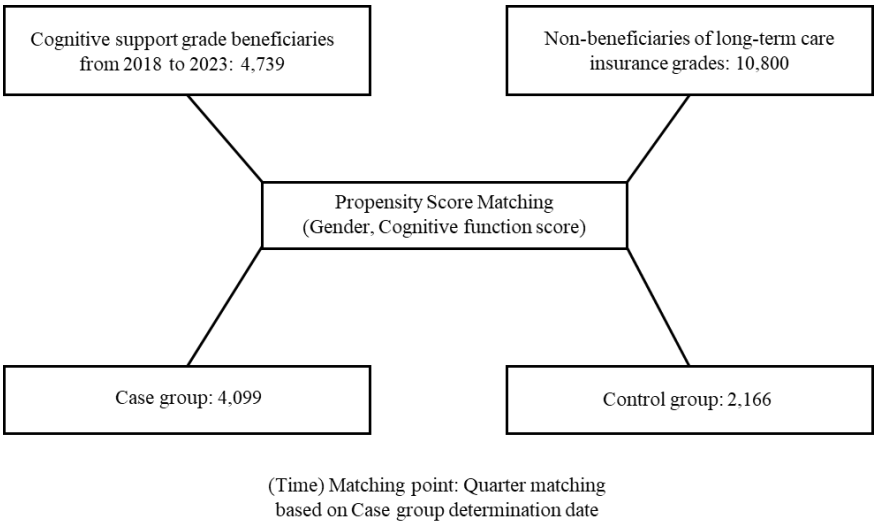

Figure 5. PS matching process for the cognitive and physical function analysis

2. Variables

The dependent variables in this analysis were the cognitive function score and the physical function score (Table 10). The cognitive function score was measured using seven items. The raw scores ranged from 0 to 7 but were converted to a range of 0 to 100 based on the long-term care eligibility scoring conversion table. Higher scores indicated a more severe cognitive impairment. The items addressed short-term memory, information recall (including current date, current location, and birthdate), comprehension of instructions, judgment, and communication ability.

The physical function score (i.e., the activities of daily living score) was measured using 12 items, including washing one's face, brushing one's teeth, dressing, overall mobility, eating, bathing, and controlling bowel and bladder functions. The raw scores ranged from 12 to 36 and were converted to a range of 0 to 100 using the scoring conversion table [8]. Higher scores indicated a greater impairment in basic daily living abilities.

Table10. Definition and measurement methods of outcome variables (cognitive and physical function) (Continued)

Variable	Definition	Measurement methods
Cognitive Function	Changes in cognitive function scores before and after the introduction of the Cognitive Assistance Grade (score = 0–100)	- Short-term memory impairment - Disorientation to date/place/birthdate - Difficulty understanding instructions - Decline in situational judgment - Communication impairment

Physical Function (Activities of Daily Living)	Changes in physical function scores before and after the introduction of the Cognitive Assistance Grade (score = 0–100)	- Dressing - Washing face - Brushing teeth - Bathing - Eating - Changing positions - Sitting up - Moving to another seat - Going outside - Using the toilet - Controlling bowel movements - Controlling urination

The independent variables used in this analysis were gender, age, income, region, insurance type, presence of a caregiver, presence of cohabitants, disability status, the Charlson Comorbidity Index (CCI), duration of grade maintenance, and wave (Table 11). Gender was classified as male or female, and age was categorized as under 70, 70–79, 80–89, and 90 or older. Income was divided into four quartiles, and residence was classified into metropolitan areas (e.g., Seoul, Incheon, Gyeonggi) or non-metropolitan areas. The type of insurance was categorized as medical aid beneficiaries, employee subscribers, or local subscribers. Additionally, the presence of a caregiver was classified as “yes” or “no,” and the presence of cohabitants was categorized as “yes” or “no.” The disability status was classified as “none,” “severe,” or “mild.” The CCI was calculated based on comorbidity data from the three years prior to the intervention point (index date) and was categorized as 0, 1, 2, 3, or 4+. The duration of grade maintenance was measured in units of 100 days from the date of grade determination, and wave was defined as a time variable in three-month intervals.

Table 11. Independent variables used for cognitive/physical function analysis

Variable		Definition
Interesting variables	Policy effect variable	Interaction term =Time dummy variable × Group dummy variable
	Time indicator variable (Policy)	Pre-intervention / Post intervention
	Group indicator variable (Case)	Case group/ Control group
Covariates	Gender	Male / Female
	Age	70-/70-79/80-89/90+
	Income level	Q1(lowest)/Q2/ Q3/ Q4(highest)
	Region	Metropolitan area / Non-metropolitan area
	Insurance type	Medical aid/Employee covered/ Local subscriber
	Presence of caregiver	Yes/ No
	Living alone	Yes/ No
	Disability	None / Severe / Mild
	CCI (Charlson Comorbidity Index)	0/1/2/3/4+
	Grade maintenance period	The grade maintenance period calculated in 100-day intervals
	Wave	Time variable in 3-month intervals

The interesting variables included the policy effect variable, the time indicator variable (policy), and the group indicator variable (case). The policy effect variable represented the interaction term between the time indicator variable (pre-intervention, post-intervention) and the group indicator variable (case group, control group). The time indicator variable (policy) distinguished between the pre- and post-intervention periods, with pre-intervention referring to the period before the policy implementation and post-intervention referring to the period after the implementation. In this study, the time variable was set based on the CAG determination, enabling the analysis of policy effects before and after the CAG's introduction. The group indicator variable (case) categorized the study

population into two groups: the case and control groups. The case group consisted of CAG beneficiaries, while the control group consisted of non-beneficiaries (Figure 6).

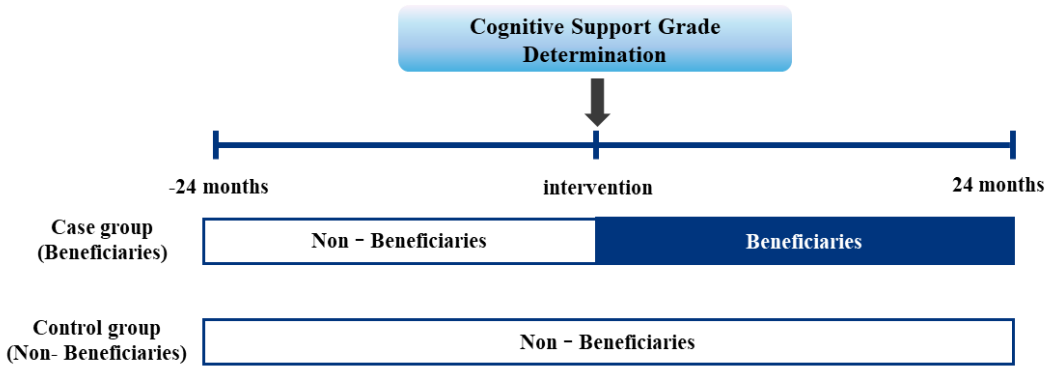

Figure 6. Beneficiary changes before and after cognitive assistance rating determination

3. Statistical methods

This study employed the Difference-in-Differences (DID) method as the primary analytical approach to assess the impact of the introduction of the CAG on health outcomes among older adults individuals with dementia. First, an analysis of descriptive statistics was conducted to comprehend the general characteristics of the study population, including demographic, socioeconomic, and health-related factors. Each variable was reported as frequency and percentage, and the differences between the two groups were compared using t-tests. Second, an analysis of variance (ANOVA) was used to assess changes in cognitive and physical functions. This compared the means and standard deviations of each variable to evaluate the differences between the two groups.

Third, the DID method was applied to evaluate the effects of the CAG on changes in cognitive and physical functions. Generalized Estimating Equations (GEE) were used to estimate the interaction term between the pre- and post-implementation periods and the case and control groups while controlling for demographic variables such as age, gender, and income. Fourth, a negative binomial regression model was employed using the GENMOD procedure with a log-link function. This approach is suitable for analyzing outcomes with asymmetric distributions and was applied to assess changes in cognitive and physical functions before and after the CAG's implementation. All analyses were conducted using SAS version 9.4, with a significance level set at p-value <0.05.

4. Ethics statement

This study was approved for exemption from review by the Institutional Review Board (IRB) of Yonsei University Health System, Severance Hospital (Approval Number: 4-2024-0241).

IV. Results

1. General characteristics of study population

Table 12 presents the general characteristics and distribution of the study population. The case group, consisting of CAG beneficiaries, included 4,099 individuals, while the control group comprised 2,166 grade-excluded participants. In both groups, females outnumbered males, with females accounting for 73.21% of the case group, a significantly higher proportion than in the control group ($p < 0.0001$).

Regarding age distribution, individuals aged 80–89 years were the most common in both groups. Additionally, the proportion of participants with a caregiver was higher in the case group (77.97%) compared to the control group.

Table 12. General characteristics of cognitive and physical functions analysis (Continued)

Variables	Baseline (matching point)				P-value
	Case (Cognitive Assistance Grade)		Control (grade-excluded)		
	N	%	N	%	
Total	4,099	100.00	2,166	100.00	
Gender					
Male	1,098	26.79	762	35.18	<.0001
Female	3,001	73.21	1,404	64.82	
Age					
70-	241	5.88	151	6.97	0.0166
70-79	1,169	28.52	608	28.07	
80-89	2,419	59.01	1,302	60.11	
90+	270	6.59	105	4.85	
Insurance type					
Local subscriber	1,011	24.66	571	26.36	0.3077
Employee covered	2,020	49.28	1,033	47.69	
Medical aid	1,068	26.06	562	25.95	
Region					
Metropolitan area	1,267	30.91	710	32.78	0.1300
Non-metropolitan area	2,832	69.09	1,456	67.22	
Income level					
Q1 (low)	1,706	41.62	929	42.89	0.6875
Q2	444	10.83	240	11.08	
Q3	628	15.32	314	14.50	
Q4 (high)	1,321	32.23	683	31.53	
Presence of caregiver					
Yes	3,196	77.97	1,628	75.16	0.0120
No	903	22.03	538	24.84	
Living alone					
Yes	2,220	54.16	1,212	55.96	0.1743
No	1,879	45.84	954	44.04	

Disability					
None	3,058	74.60	1,514	69.90	
Severe	156	3.81	146	6.74	<.0001
Mild	885	21.59	506	23.36	
CCI (Charlson comorbidity index)					
0	566	13.81	303	13.99	
1	929	22.66	476	21.98	
2	829	20.22	414	19.11	0.6855
3	623	15.20	333	15.37	
4+	1152	28.10	640	29.55	

2. Changes of cognitive function score of beneficiaries

Table 13 presents the changes in cognitive function scores before and after the introduction of the CAG for both the case and control groups. Among the case group, which received the CAG, the cognitive function score increased from an average of 34.55 points before the introduction to 41.91 points after. In the control group, the score rose from an average of 25.88 points before the introduction to 35.63 points after. Overall, the case group exhibited higher cognitive function scores than the control group, indicating more severe cognitive impairment.

3. Changes of physical function score of beneficiaries

Table 14 presents the changes in the physical function scores (i.e., the activities of daily life) before and after the introduction of the CAG for the case and control groups. In the case group, which received CAG benefits, the physical function score increased from an average of 15.57 points before the introduction to 17.47 points after. In the control group, the score rose from an average of 17.11 points before the introduction to 19.66 points after. As higher physical function scores indicate more severe impairment, these results suggest a deterioration in physical function for both groups following the introduction of the CAG. Figure 7 shows how the primary dependent variables changed with time for case and control groups.

Table13. Changes in cognitive function scores before and after the introduction of the Cognitive Assistance Grade (Continued)

Variables	Pre-intervention period							Post-intervention period						
	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*
	Mean	±	SD	Mean	±	SD		Mean	±	SD	Mean	±	SD	
Total	34.55		14.06	25.88		10.75		41.91		15.32	35.63		14.98	
Gender														
Male	31.45	±	12.83	25.32	±	10.22	<.0001	38.11	±	14.91	32.56	±	13.99	<.0001
Female	35.69	±	14.32	26.16	±	11.04	<.0001	43.14	±	15.16	36.90	±	15.11	<.0001
Age														
70-	31.97	±	13.19	27.21	±	7.96	0.0091	37.25	±	14.57	34.56	±	16.81	0.0179
70-79	33.46	±	13.90	24.74	±	7.39	<.0001	39.92	±	15.01	35.23	±	14.20	<.0001
80-89	35.18	±	14.06	25.57	±	12.95	<.0001	42.58	±	15.18	35.21	±	14.80	<.0001
90+	38.25	±	14.99	46.73	±	24.03	0.3356	45.76	±	15.69	38.71	±	15.89	<.0001
Insurance type														
Local subscriber	35.34	±	14.05	29.87	±	14.33	0.0642	42.96	±	15.42	36.37	±	15.68	<.0001
Employee covered	35.37	±	13.91	25.16	±	11.84	<.0001	42.01	±	14.92	35.50	±	14.62	<.0001
Medical aid	32.43	±	14.13	25.20	±	7.91	<.0001	40.35	±	15.59	34.18	±	14.39	<.0001
Region														
Metropolitan area	35.69	±	14.59	26.22	±	12.04	<.0001	42.52	±	15.64	36.18	±	15.26	<.0001
Non-metropolitan area	34.05	±	13.78	25.75	±	10.24	<.0001	41.50	±	15.08	35.00	±	14.67	<.0001
Income level														
Q1 (low)	33.65	±	14.19	25.15	±	8.13	<.0001	41.63	±	15.56	34.92	±	14.67	<.0001

Q2	34.80	±	13.71	29.50	±	13.80	0.1693	43.37	±	15.64	35.96	±	15.00	<.0001
Q3	35.49	±	13.71	27.36	±	8.25	0.001	41.76	±	14.66	35.37	±	15.47	<.0001
Q4 (high)	35.24	±	14.10	25.58	±	15.09	<.0001	41.55	±	14.95	35.85	±	14.83	<.0001
Presence of caregiver														
Yes	32.44	±	13.45	24.20	±	10.17	<.0001	39.57	±	15.19	33.85	±	14.36	<.0001
No	35.19	±	14.18	26.64	±	10.96	<.0001	42.39	±	15.23	35.87	±	15.00	<.0001
Living alone														
Yes	35.81	±	14.13	26.57	±	11.42	<.0001	43.09	±	15.32	35.98	±	15.00	<.0001
No	33.50	±	13.92	25.53	±	10.43	<.0001	40.68	±	15.12	34.93	±	14.76	<.0001
Disability														
None	34.69	±	14.00	25.16	±	10.17	<.0001	41.86	±	15.09	35.82	±	14.79	<.0001
Severe	36.61	±	15.61	30.61	±	17.08	0.2112	42.33	±	16.49	36.41	±	17.13	<.0001
Mild	33.75	±	13.95	26.07	±	9.83	<.0001	41.54	±	15.58	33.71	±	14.20	<.0001
CCI (Charlson comorbidity index)														
0	36.50	±	14.02	28.94	±	19.22	0.0968	42.35	±	14.79	37.10	±	15.65	<.0001
1	35.35	±	13.98	24.73	±	10.25	<.0001	42.83	±	15.36	36.46	±	15.58	<.0001
2	35.24	±	14.15	26.90	±	9.58	0.0002	41.73	±	15.05	35.12	±	14.25	<.0001
3	34.36	±	14.23	25.87	±	9.11	0.0002	41.64	±	15.40	35.11	±	14.69	<.0001
4+	32.73	±	13.79	24.91	±	7.58	<.0001	40.88	±	15.42	34.09	±	14.34	<.0001

Table14. Changes in physical function scores before and after the introduction of the Cognitive Assistance Grade (Continued)

Variables	Pre-intervention period						*P-value*	Post-intervention period						*P-value*
	Case (Cognitive Assistance Grade)			Control (grade-excluded)				Case (Cognitive Assistance Grade)			Control (grade-excluded)			
	Mean	±	SD	Mean	±	SD		Mean	±	SD	Mean	±	SD	
Total	15.57	±	5.39	17.11	±	5.03		17.47	±	6.5033	19.66	±	6.6	
Gender														
Male	15.54	±	5.21	16.90	±	5.04	0.0629	17.19	±	6.35	19.01	±	6.26	<.0001
Female	15.59	±	5.46	17.22	±	5.05	0.0026	17.35	±	6.51	19.73	±	6.62	<.0001
Age														
70-	15.25	±	5.17	14.70	±	3.45	0.3792	16.51	±	5.61	18.89	±	6.51	<.0001
70-79	15.75	±	5.59	17.61	±	5.23	0.0059	16.73	±	6.11	19.59	±	6.53	<.0001
80-89	15.58	±	5.42	17.72	±	5.15	0.0021	17.47	±	6.56	19.47	±	6.44	<.0001
90+	14.78	±	3.83	13.19	±	0.00	<.0001	18.66	±	7.18	19.66	±	7.07	0.0254
Insurance type														
Local subscriber	15.33	±	5.18	15.94	±	4.26	0.5750	17.52	±	6.63	19.45	±	6.51	<.0001
Employee covered	15.76	±	5.72	17.24	±	4.84	0.0411	17.44	±	6.59	19.95	±	6.66	<.0001
Medical aid	15.45	±	4.98	17.39	±	5.42	0.0016	16.88	±	6.04	18.71	±	6.16	<.0001
Region														
Metropolitan area	15.83	±	5.41	16.00	±	4.46	0.8338	17.46	±	6.69	19.70	±	6.36	<.0001
Non-metropolitan area	15.46	±	5.39	17.56	±	5.19	<.0001	17.25	±	6.36	19.37	±	6.57	<.0001
Income level														
Q1 (low)	15.43	±	5.00	17.07	±	5.24	0.0031	17.27	±	6.33	19.00	±	6.31	<.0001

Q2	14.89	±	4.72	14.58	±	3.40	0.8132	17.47	±	6.64	19.30	±	6.20	<.0001
Q3	15.99	±	5.62	17.21	±	4.63	0.3618	17.22	±	6.39	20.17	±	6.31	<.0001
Q4 (high)	15.82	±	5.97	18.02	±	5.06	0.0246	17.36	±	6.63	19.92	±	6.92	<.0001
Presence of caregiver														
Yes	14.55	±	3.65	16.64	±	4.84	0.0046	16.29	±	5.39	17.88	±	5.56	<.0001
No	15.89	±	5.79	17.33	±	5.12	0.0112	17.57	±	6.69	19.99	±	6.70	<.0001
Living alone														
Yes	16.06	±	6.06	17.05	±	5.37	0.2417	17.92	±	7.10	20.45	±	6.92	<.0001
No	15.16	±	4.73	17.14	±	4.87	<.0001	16.78	±	5.79	18.75	±	6.08	<.0001
Disability														
None	15.56	±	5.40	18.22	±	5.29	<.0001	17.31	±	6.47	19.53	±	6.49	<.0001
Severe	15.55	±	5.26	13.94	±	2.61	0.079	17.81	±	6.77	18.54	±	6.01	0.1515
Mild	15.63	±	5.41	15.84	±	4.37	0.782	17.21	±	6.39	19.61	±	6.68	<.0001
CCI (Charlson comorbidity index)														
0	15.09	±	5.13	16.36	±	4.43	0.2747	17.52	±	6.62	19.07	±	6.20	<.0001
1	15.48	±	5.30	17.55	±	5.45	0.0326	17.32	±	6.50	19.28	±	6.27	<.0001
2	15.38	±	5.41	16.77	±	5.22	0.1936	17.30	±	6.43	19.51	±	6.30	<.0001
3	15.86	±	5.42	17.82	±	5.37	0.0823	17.19	±	6.37	19.51	±	6.71	<.0001
4+	15.84	±	5.54	16.99	±	4.86	0.1338	17.27	±	6.44	19.77	±	6.83	<.0001

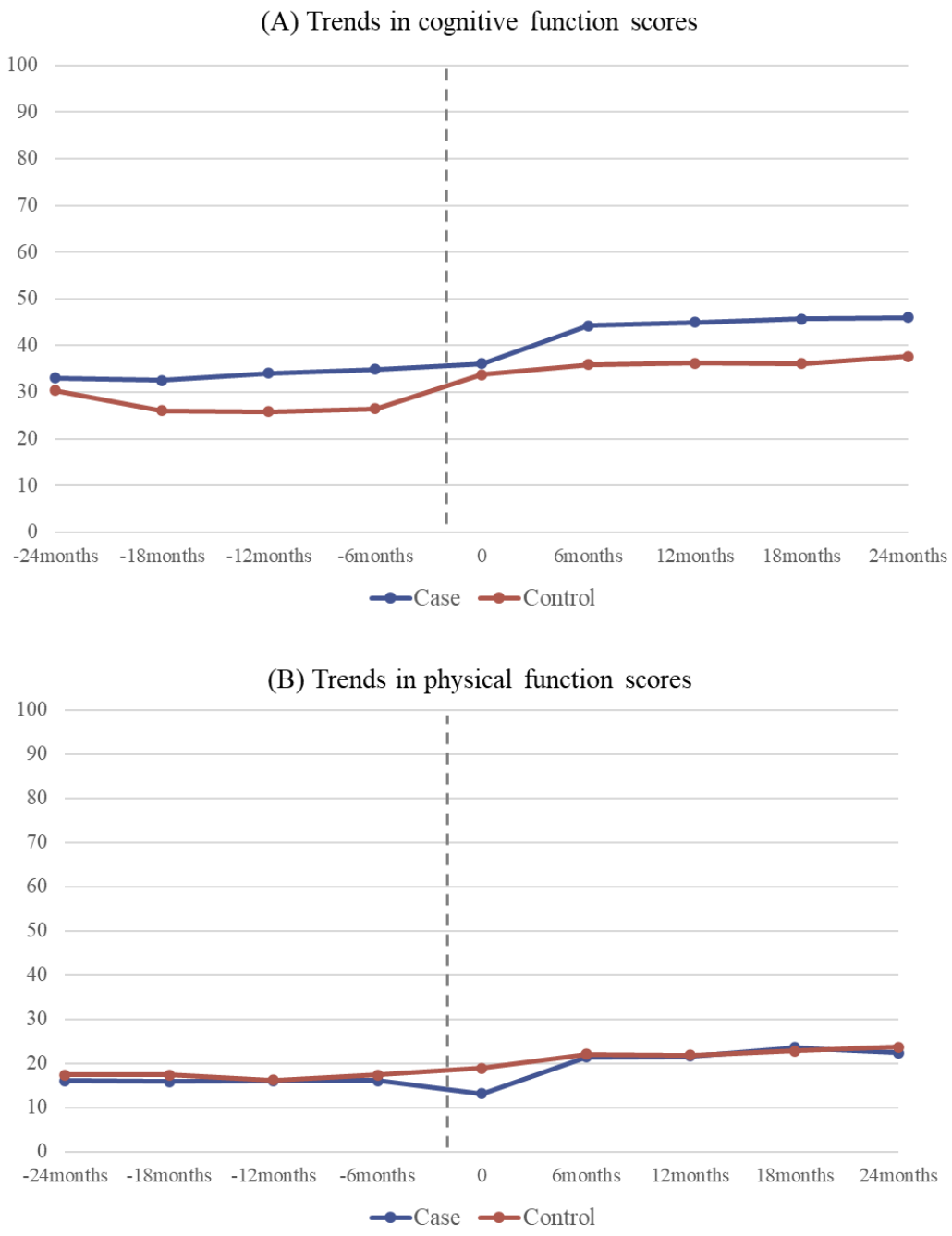

Figure 7. Trends in the mean values of primary dependent variables for the case and control groups

4. Differential changes in cognitive function and problem behavior scores between the intervention and control groups

Table 15 compares changes in cognitive and physical function scores before and after the introduction of the CAG between the case and control groups. The analysis showed that the case group exhibited a significantly greater increase in their cognitive function score compared to the control group ($\beta = 0.2975$, $\exp(\beta) = 1.3465$, $p < 0.0001$). However, the interaction term between the policy implementation and the group was found to be significantly negative ($\beta = -0.1564$, $\exp(\beta) = 0.8552$, $p < 0.0001$), suggesting that the introduction of the policy contributed to mitigating cognitive decline in the case group compared to the control group.

In the analysis of the physical function scores, the interaction term was not statistically significant ($\beta = 0.0356$, $\exp(\beta) = 1.0362$, $p = 0.2313$). This indicates that the introduction of the CAG did not have a significant impact on changes to physical function for beneficiaries. However, specific factors such as gender, caregiver presence, and cohabitant presence were found to significantly affect physical functioning. The absence of a caregiver ($\beta = 0.0596$, $\exp(\beta) = 1.0614$, $p < 0.0001$) and the presence of cohabitants ($\beta = 0.0446$, $\exp(\beta) = 1.0456$, $p < 0.0001$) were both associated with deterioration in physical functions. The introduction of the CAG thus had a positive effect in slowing cognitive decline but did not result in a significant improvement in physical functioning.

Table15. Results of the difference-in-differences analysis of changes in cognitive and physical function scores (Continued)

Variables	Cognitive Function Score				Physical Function Score (Basic Activities of Daily Living Score)			
	β	exp(β)	SE	*P-value*	β	exp(β)	SE	*P-value*
Wave (3 months)	0.0073	1.0073	0.0004	<.0001	0.0144	1.0145	0.0004	<.0001
Grade maintenance period (100day units)	−0.004	0.9960	0.001	0.0001	−0.0081	0.9919	0.0009	<.0001
Policy								
Pre-intervention	Ref				Ref			
Post-intervention	0.2048	1.2273	0.0368	<.0001	−0.1677	0.8456	0.0298	<.0001
Control (non-graded)	Ref				Ref			
Case (Cognitive Assistance Grade)	0.2975	1.3465	0.0367	<.0001	−0.1841	0.8319	0.0293	<.0001
Case*Policy	−0.1564	0.8552	0.0367	<.0001	0.0356	1.0362	0.0297	0.2313
Gender								
Male	Ref				Ref			
Female	0.1182	1.1255	0.0087	<.0001	0.0183	1.0185	0.0057	0.0014
Age								
70-	Ref				Ref			
70-79	0.0173	1.0175	0.0176	0.3253	0.0203	1.0205	0.0112	0.0704
80-89	0.0426	1.0435	0.0172	0.0136	0.0253	1.0256	0.011	0.0217
90+	0.1057	1.1115	0.021	<.0001	0.0407	1.0415	0.014	0.0036
Insurance type								
Local subscriber	Ref				Ref			
Employee covered	−0.0077	0.9923	0.0091	0.3999	0.0094	1.0094	0.007	0.1788

Medical aid	−0.0445	0.9565	0.0119	0.0002	−0.0064	0.9936	0.0083	0.4394
Region								
Metropolitan area	Ref				Ref			
Non-metropolitan area	−0.0261	0.9742	0.0081	0.0012	−0.0065	0.9935	0.0054	0.2291
Income level								
Q1 (low)	Ref				Ref			
Q2	−0.0102	0.9899	0.0121	0.3984	−0.0264	0.9739	0.0096	0.0057
Q3	−0.022	0.9782	0.0119	0.065	−0.0080	0.9920	0.0094	0.3925
Q4 (high)	−0.0276	0.9728	0.011	0.0125	−0.0102	0.9899	0.0086	0.2337
Presence of caregiver								
Yes	Ref				Ref			
No	0.0429	1.0438	0.0078	<.0001	0.0596	1.0614	0.0061	<.0001
Living alone								
Yes	Ref				Ref			
No	0.0447	1.0457	0.0072	<.0001	0.0446	1.0456	0.0056	<.0001
Disability								
None	Ref				Ref			
Severe	0.0607	1.0626	0.0196	0.0019	−0.0029	0.9971	0.0125	0.8153
Mild	−0.0105	0.9896	0.0089	0.2382	0.002	1.0020	0.0062	0.7499
CCI (Charlson comorbidity index)								
0	Ref				Ref			
1	−0.0036	0.9964	0.0129	0.7784	0.0079	1.0079	0.0085	0.3534
2	−0.0185	0.9817	0.0132	0.1618	0.007	1.0070	0.0087	0.4212

3	−0.0238	0.9765	0.014	0.0904	0.0143	1.0144	0.0094	0.1299
4+	−0.0403	0.9605	0.0126	0.0013	0.0237	1.0240	0.0083	0.0044

5. Effects of the Cognitive Assistance Grade on healthcare utilization

The impact of the CAG policy on healthcare utilization is discussed in Appendices 1–8. The results demonstrated that the CAG policy led to an overall reduction in outpatient visits ($\beta = -0.0593$, $\exp(\beta) = 0.9420$, $p < 0.0001$) and expenditures for outpatient services ($\beta = -0.1085$, $\exp(\beta) = 0.8972$, $p < 0.0001$). Conversely, the policy resulted in a significant increase in the length of inpatient stays ($\beta = 0.1815$, $\exp(\beta) = 1.1990$, $p < 0.0001$) and medical expenditures ($\beta = 0.2730$, $\exp(\beta) = 1.3139$, $p < 0.0001$). Total healthcare expenditures showed a modest but significant increase ($\beta = 0.0953$, $\exp(\beta) = 1.1000$, $p < 0.0001$).

V. Discussion

1. Discussion of the study method

This study evaluated the impact of the introduction of the CAG policy under the LTCI system in South Korea on the cognitive and physical functions of older adults with dementia. The data used for the study were collected from the NHIS between 2014 and 2024, and the study utilized a nationwide dataset comprising all individuals who had been assessed for the CAG as of June 2024 (totaling 106,808) and a 25% random sample of individuals aged 57–80 as of 2014. By including the entire population of policy beneficiaries, this study aimed to enhance the accuracy of its analysis.

To assess the changes in the policy target group following the implementation of the CAG, the Difference-in-Differences (DID) method was employed. DID is a widely-used policy evaluation tool in public health that estimates causal effects by comparing outcome changes before and after policy implementation between the treatment (i.e., the policy target demographic) and control groups. This method removes the influence of time-related exogenous factors that may arise from simple pre- and post-comparisons, enabling the identification of the pure effect of the policy.

In addition, this study adopted a quasi-experimental model combining Propensity Score Matching (PSM) with DID analysis to estimate the pure treatment effect of receiving the CAG benefits. This approach involved selecting a control group with similar characteristics to the case group through PSM and calculating the treatment effect estimates based on the matched sample. By integrating PSM and DID, this approach addressed the limitations of non-experimental data and

mitigated issues related to the selection bias inherent in DID analysis. This analytical framework effectively controlled for pre-existing differences between the case and control groups, minimized confounding variables caused by exogenous factors, and identified the effects of treatment, thus offering a robust method for evaluating the impact of policy.

To evaluate the appropriateness of matching, the kernel density changes in the propensity scores before and after matching were compared (Appendix 9). In both the cognitive and physical function analyses, the left-hand graphs (pre-matching) showed a clear difference in the propensity score distributions between the case and control groups. In Appendix 9, the propensity score distribution for the case group was skewed to the right, while that of the control group was skewed to the left. These differences indicated substantial pre-matching disparities between the groups in both analyses.

Post-matching (right-hand graphs), the kernel density curves of the case and control groups aligned closely in the figures, demonstrating that PSM significantly improved the comparability of the groups. This indicates that the PSM was successful at minimizing the differences between the groups.

The comparison of means, standard deviations (SD), and standardized mean differences (SMD) for matching variables between the case and control groups before and after matching is presented in Appendix 10. In the analyses of cognitive and physical function, significant differences were observed pre-matching between the two groups for age and cognitive function scores. The SMD for age was 0.4667, and 0.4996 for cognitive function scores, indicating substantial differences between the groups. However, post-matching, these differences were markedly reduced. The SMD for age decreased to 0.1264 and to 0.1284 for the cognitive function scores. Since an SMD below 0.1 can generally be interpreted as negligible, these results suggest that matching greatly improved the homogeneity between the two groups. Only age and cognitive function scores were used as matching

variables to maximize the sample size for the cognitive and physical function analyses. However, to enhance the precision of the analyses and the reliability of the results, additional matching variables—including gender, cognitive function scores, disability status, and date of grade determination—were included in the supplementary analyses (Appendices 11–13). These supplementary analyses yielded trends similar to the main results of this study, thus providing additional evidence supporting the reliability of the findings.

2. Discussion of study results

The analysis results indicate that after the introduction of the CAG policy, the cognitive decline of beneficiaries was significantly less pronounced compared to that of non-beneficiaries. This finding suggests that the CAG policy played an effective role in slowing cognitive decline, highlighting its importance for dementia prevention and management. However, its limited impact on physical function underscores the ongoing need for tailored interventions focusing on physical activity and rehabilitation.

These findings aligned with previous research that demonstrates that cognitive training can be effective for improving and maintaining cognitive function, emphasizing the importance of direct cognitive management programs [34, 35, 48]. Previous studies reported that individuals participating in integrated dementia management programs showed significant improvements in their cognitive function immediately after program completion, which remained apparent four weeks later. In addition, an increased utilization of day and night care services was associated with significant improvements in behaviors [48].

Beneficiaries of the CAG policy are required to participate in cognitive activity programs when utilizing day and night care facilities. These programs likely played a crucial role in fostering increased interpersonal interactions and activities, which are common non-pharmacological treatments that improve cognitive function in patients with dementia. Another potential reason for the positive impact of the CAG policy on cognitive function is that the beneficiaries were primarily individuals with early-stage or mild dementia. Management strategies for dementia differ depending on its progression and severity, with early interventions being particularly critical. Proper cognitive management programs and non-pharmacological interventions during the early and mild stages of

dementia can effectively slow the progression of the disease. In this regard, the CAG policy likely contributed to improving the efficiency of dementia care by providing appropriate programs and resources tailored to individuals with early-stage dementia.

In contrast, the results for changes in physical function were not significant. This may have been due to the cognitive activity programs offered at day and night care facilities, which are primarily designed to improve cognitive function. The result suggests that support for physical health management, caregiving, and rehabilitation may have been insufficient relative to the support provided for cognitive functioning. Therefore, it is recommended that cognitive activity programs at these facilities adopt an integrated approach that incorporates not only paper-based activities for cognitive stimulation but also physical activities aimed at enhancing the performance of daily life activities. Further, the results highlight the need for systematic and personalized management tailored to the characteristics of patients with dementia.

Despite producing meaningful findings that will contribute to improving the management of dementia care in South Korea, this study has several limitations. Participants were limited to those who had previously received a “grade-excluded” determination. This selection criterion constrained the study population. To develop more refined policy improvement measures, future research should establish methods for the long-term follow-up measurement of participants’ cognitive and physical functions and employ larger sample sizes for continued investigation.

Furthermore, the absence of an objective dementia evaluation tool posed limitations in reflecting the individual severity of dementia. To mitigate this, proxy variables such as the CCI and disability status were utilized to conduct the analysis, thereby minimizing this constraint. There were also data-related limitations when accurately reflecting income levels. While income levels were compared using quartiles based on medical aid and health insurance eligibility criteria (e.g., employee or regional subscriber), differences in the calculation criteria for health insurance

premiums limited the accurate reflection of income levels. Finally, this study included only participants who utilized the services provided under the CAG policy, but it did not account for the individual extent of service usage. While this approach ensured that the analyses focused on actual service users, the absence of data on the frequency or intensity of service utilization limited the assessment of its differential effects on cognitive and physical functioning. Future studies should incorporate detailed service usage data to better evaluate the relationship between the degree of service utilization and its outcomes. Further studies are therefore needed to address these limitations and expand the scope of the evaluation to include broader dimensions of dementia care.

The impact of the CAG policy on healthcare utilization is discussed in Appendices 1–8. The reduction in outpatient service utilization highlights a notable change in healthcare usage patterns. In contrast, the policy was associated with an increase in inpatient length of stay and medical expenditures, suggesting the need for integrated management strategies. These findings underline the necessity of comprehensive support programs to balance healthcare service use and improve outcomes for vulnerable older adults. Detailed analyses and discussions about these findings will be addressed in subsequent studies.

VI. Conclusion

This study provides evidence for the effectiveness of the introduction of the CAG policy in slowing cognitive decline among patients with dementia, underscoring its pivotal role in preventive dementia care. However, the lack of significant improvements in physical function highlights the need to integrate physical rehabilitation and personalized support programs into the policy framework to enhance its overall impact. This study strengthens the evidence base for dementia care policies by demonstrating the success of the CAG policy success in mitigating cognitive decline. Future research should explore the policy's long-term impact on overall quality of life, healthcare expenditures, and disease progression. Such efforts would provide critical insights to further refine dementia care strategies and promote equitable access to preventive services at the national and global level.

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Appendix

Appendix1. General characteristics of healthcare utilization analysis (Continued)

Variables	Baseline				P-value
	Case (Cognitive Assistance Grade)		Control (grade-excluded)		
	N	%	N	%	
Total	13,672	100.00	13,672	100.00	
Gender					
Male	2,872	21.01	2,867	20.97	0.9408
Female	10,800	78.99	10,805	79.03	
Age					
70-	1,105	8.08	1,105	8.08	0.4865
70-79	5,549	40.59	5,552	40.61	
80-89	6,642	48.58	6,674	48.82	
90+	376	2.75	341	2.49	
Insurance type					
Local subscriber	3,300	24.14	3,328	24.34	0.3240
Employee covered	8,472	61.97	8,529	62.38	
Medical aid	1,900	13.90	1,815	13.28	
Region					
Metropolitan area	5,313	38.86	5,258	38.46	0.4946
Non-metropolitan area	8,359	61.14	8,414	61.54	
Income level					
Q1 (low)	3,759	27.49	3,697	27.04	0.8536
Q2	1,602	11.72	1,598	11.69	
Q3	2,287	16.73	2,307	16.87	
Q4 (high)	6,024	44.06	6,070	44.40	
Disability					
None	10,945	80.05	10,914	79.83	<.0001
Severe	253	1.85	397	2.90	
Mild	2,474	18.10	2,361	17.27	
CCI (Charlson comorbidity index)					
0	210	1.54	1,318	9.64	<.0001
1	3,705	27.10	3,600	26.33	

2	3,979	29.10	3,561	26.05
3	2,601	19.02	2,375	17.37
4+	3,177	23.24	2,818	20.61

Appendix2. Changes in outpatient visits before and after the introduction of the Cognitive Assistance Grade (Continued)

Variables	Pre-intervention period							Post-intervention period						
	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*
	Mean	±	SD	Mean	±	SD		Mean	±	SD	Mean	±	SD	
Total	18.60	±	19.20	18.81	±	17.71		15.08	±	16.50	17.39	±	17.05	
Gender														
Male	18.90	±	20.22	18.90	±	19.58	0.9728	16.12	±	17.91	17.86	±	19.14	<.0001
Female	18.52	±	18.92	18.78	±	17.18	0.0322	14.80	±	16.10	17.27	±	16.45	<.0001
Age														
70-	14.52	±	18.40	16.95	±	19.40	<.0001	12.71	±	16.06	14.41	±	20.78	<.0001
70-79	19.86	±	19.53	20.66	±	17.70	<.0001	16.31	±	17.73	20.00	±	17.14	<.0001
80-89	18.44	±	18.84	17.32	±	16.80	<.0001	14.86	±	15.80	16.53	±	16.10	<.0001
90+	15.57	±	20.48	9.15	±	11.78	<.0001	12.47	±	15.23	9.43	±	14.36	<.0001
Insurance type														
Local subscriber	17.79	±	18.93	18.12	±	17.26	0.1375	14.42	±	16.26	16.80	±	16.46	<.0001
Employee covered	17.66	±	18.23	18.76	±	17.14	<.0001	14.07	±	15.20	17.28	±	16.42	<.0001
Medical aid	24.36	±	22.74	20.36	±	20.91	<.0001	20.44	±	20.62	19.06	±	20.58	<.0001
Region														
Metropolitan area	16.54	±	16.91	17.71	±	15.92	<.0001	13.51	±	14.05	16.59	±	15.81	<.0001
Non-metropolitan area	19.90	±	20.41	19.49	±	18.70	0.0066	16.08	±	17.82	17.89	±	17.76	<.0001
Income level														
Q1 (low)	21.18	±	21.22	19.39	±	19.71	<.0001	17.34	±	18.89	17.95	±	18.83	0.0042
Q2	17.41	±	18.43	18.88	±	18.47	<.0001	14.01	±	14.85	17.52	±	17.96	<.0001

Q3	17.10	±	17.90	18.59	±	17.02	<.0001	13.84	±	14.65	16.64	±	15.44	<.0001
Q4 (high)	17.89	±	18.42	18.51	±	16.41	<.0001	14.28	±	15.66	17.29	±	16.16	<.0001
Disability														
None	17.79	±	18.54	18.40	±	17.05	<.0001	14.18	±	15.44	17.00	±	16.45	<.0001
Severe	20.67	±	21.75	15.67	±	21.78	<.0001	19.82	±	23.03	15.39	±	20.73	<.0001
Mild	22.15	±	21.49	21.23	±	19.80	0.0022	18.31	±	19.11	19.63	±	18.64	<.0001
CCI (Charlson comorbidity index)														
0	13.15	±	15.71	13.70	±	15.35	0.3355	11.59	±	11.54	13.92	±	15.16	<.0001
1	12.39	±	13.75	15.20	±	15.46	<.0001	10.78	±	12.10	14.21	±	14.82	<.0001
2	16.63	±	17.12	17.96	±	16.83	<.0001	13.35	±	14.10	16.73	±	16.53	<.0001
3	20.93	±	19.51	21.26	±	17.58	0.2124	16.52	±	16.90	19.37	±	16.86	<.0001
4+	26.74	±	23.44	24.80	±	20.41	<.0001	21.32	±	21.06	22.25	±	19.78	0.0004

Appendix3. Changes in inpatient length of stay before and after the introduction of the Cognitive Assistance Grade (Continued)

Variables	Pre-intervention period							Post-intervention period						
	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*
	Mean	±	SD	Mean	±	SD		Mean	±	SD	Mean	±	SD	
Total	5.88	±	25.88	15.53	±	47.96		10.03	±	36.11	17.16	±	51.36	
Gender														
Male	10.96	±	38.25	13.57	±	44.63	<.0001	12.88	±	42.12	14.89	±	47.66	0.0007
Female	4.53	±	21.21	16.05	±	48.79	<.0001	9.27	±	34.30	17.76	±	52.28	<.0001
Age														
70-	14.83	±	44.88	11.29	±	39.85	<.0001	15.16	±	46.73	12.99	±	44.10	0.0257
70-79	5.24	±	23.39	9.22	±	36.07	<.0001	9.95	±	35.73	8.29	±	34.71	<.0001
80-89	4.26	±	20.69	24.08	±	59.54	<.0001	9.16	±	34.07	20.57	±	56.16	<.0001
90+	6.83	±	29.21	72.62	±	88.22	<.0001	12.43	±	41.06	71.78	±	89.40	<.0001
Insurance type														
Local subscriber	5.14	±	23.59	16.32	±	49.26	<.0001	8.98	±	34.10	18.61	±	53.48	<.0001
Employee covered	3.96	±	19.73	11.92	±	42.01	<.0001	8.26	±	32.38	12.91	±	44.70	<.0001
Medical aid	16.10	±	45.24	31.69	±	65.96	<.0001	19.28	±	50.16	33.96	±	69.25	<.0001
Region														
Metropolitan area	4.77	±	23.84	8.52	±	35.15	<.0001	7.64	±	31.23	9.48	±	38.16	<.0001
Non-metropolitan area	6.59	±	27.06	19.89	±	53.97	<.0001	11.56	±	38.82	21.94	±	57.56	<.0001
Income level														
Q1 (low)	10.90	±	36.97	25.85	±	60.81	<.0001	14.99	±	44.52	28.49	±	64.60	<.0001
Q2	4.61	±	22.01	13.94	±	45.26	<.0001	8.84	±	33.96	15.79	±	49.42	<.0001

Q3	4.74	±	22.32	13.09	±	43.91	<.0001	8.14	±	32.01	14.12	±	46.50	<.0001
Q4 (high)	3.56	±	18.21	10.56	±	39.50	<.0001	7.65	±	30.95	11.45	±	42.12	<.0001
Disability														
None	5.32	±	24.39	13.62	±	44.97	<.0001	9.66	±	35.59	15.28	±	48.62	<.0001
Severe	14.47	±	43.75	67.09	±	86.32	<.0001	19.42	±	51.20	62.82	±	86.36	<.0001
Mild	7.77	±	30.08	17.36	±	50.07	<.0001	10.24	±	35.41	16.21	±	49.31	<.0001
CCI (Charlson comorbidity index)														
0	1.82	±	10.87	4.62	±	25.61	<.0001	8.77	±	34.07	5.43	±	28.05	0.0071
1	5.62	±	28.19	20.99	±	56.29	<.0001	8.53	±	34.34	22.40	±	58.67	<.0001
2	5.10	±	24.86	15.18	±	47.81	<.0001	9.82	±	35.97	16.99	±	51.32	<.0001
3	5.09	±	22.13	13.30	±	43.85	<.0001	9.92	±	35.38	14.95	±	47.75	<.0001
4+	8.08	±	27.66	15.98	±	46.87	<.0001	12.23	±	38.82	18.01	±	51.74	<.0001

Appendix4. Changes in outpatient healthcare expenditure before and after the introduction of the Cognitive Assistance Grade (Continued)

Variables	Pre-intervention period							Post-intervention period						
	Case (Cognitive Assistance Grade)			Control (grade-excluded)				Case (Cognitive Assistance Grade)			Control (grade-excluded)			
	Mean	±	SD	Mean	±	SD	*P-value*	Mean	±	SD	Mean	±	SD	*P-value*
Total	654,582	±	753,532	632,052	±	829,320		633,766	±	840,789	692,087	±	1,013,929	
Gender														
Male	694,892	±	820,696	711,917	±	1,106,324	0.1855	703,704	±	939,247	804,269	±	1,481,897	<.0001
Female	643,862	±	734,276	610,860	±	737,146	<.0001	615,168	±	811,599	662,320	±	844,963	<.0001
Age														
70-	584,971	±	742,997	622,760	±	1,003,466	0.0109	603,504	±	799,481	646,002	±	1,172,187	0.0455
70-79	711,619	±	820,853	706,084	±	883,657	0.4619	715,119	±	986,502	823,022	±	1,051,236	<.0001
80-89	620,696	±	682,148	544,608	±	650,458	<.0001	602,527	±	759,850	630,042	±	970,091	0.0002
90+	461,987	±	546,216	278,813	±	401,850	<.0001	454,797	±	548,951	322,052	±	513,008	<.0001
Insurance type														
Local subscriber	624,935	±	704,653	608,951	±	829,757	0.0895	609,671	±	855,063	672,625	±	986,930	<.0001
Employee covered	610,076	±	727,363	616,749	±	818,261	0.2599	581,250	±	786,513	669,360	±	1,018,355	<.0001
Medical aid	913,619	±	892,350	752,146	±	871,338	<.0001	895,020	±	974,721	835,298	±	1,033,674	0.0003
Region														
Metropolitan area	636,254	±	731,768	652,150	±	963,844	0.0567	626,802	±	840,781	723,214	±	1,175,659	<.0001
Non-metropolitan area	666,169	±	766,758	619,555	±	733,075	<.0001	638,202	±	840,777	672,714	±	898,175	<.0001
Income level														
Q1 (low)	769,819	±	936,628	687,345	±	951,858	<.0001	737,004	±	919,439	755,461	±	1,071,132	0.1024
Q2	587,756	±	635,928	610,250	±	741,350	0.0676	558,277	±	622,416	667,543	±	951,389	<.0001

Q3	590,555	±	688,903	613,631	±	871,827	0.0419	562,162	±	633,604	634,621	±	862,372	<.0001
Q4 (high)	625,681	±	665,826	611,166	±	747,048	0.0247	610,677	±	897,797	680,398	±	1,044,401	<.0001
Disability														
None	625,687	±	730,776	603,304	±	678,445	<.0001	592,445	±	748,750	664,148	±	917,924	<.0001
Severe	848,493	±	1,052,620	1,003,868	±	2,715,482	0.0648	1,070,078	±	2,125,518	924,281	±	2,305,633	0.0536
Mild	773,147	±	812,542	717,625	±	894,812	<.0001	749,560	±	849,108	772,781	±	980,943	0.0805
CCI (Charlson comorbidity index)														
0	443,406	±	552,356	427,510	±	513,357	0.4344	500,050	±	567,530	532,759	±	734,906	0.1381
1	456,805	±	510,233	475,732	±	512,052	0.0016	474,227	±	571,776	535,311	±	697,610	<.0001
2	568,374	±	574,995	577,903	±	594,664	0.1582	550,160	±	636,121	645,431	±	820,872	<.0001
3	716,041	±	882,590	716,028	±	973,472	0.9992	673,863	±	951,766	774,401	±	1,285,610	<.0001
4+	956,840	±	956,962	925,068	±	1,219,437	0.0261	900,543	±	1,131,073	956,470	±	1,322,015	0.0005

Appendix5. Changes in inpatient healthcare expenditure before and after the introduction of the Cognitive Assistance Grade (Continued)

Variables	Pre-intervention period							Post-intervention period						
	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*
	Mean	±	SD	Mean	±	SD		Mean	±	SD	Mean	±	SD	
Total	791,003	±	2,724,836	1,558,246	±	4,356,003		1,307,706	±	4,211,736	1,783,200	±	4,825,355	
Gender														
Male	1,215,394	±	3,472,992	1,456,256	±	4,144,184	<.0001	1,548,371	±	4,628,452	1,736,138	±	4,969,515	0.0031
Female	678,146	±	2,476,139	1,585,308	±	4,410,150	<.0001	1,243,707	±	4,091,462	1,795,688	±	4,786,356	<.0001
Age														
70-	1,443,386	±	3,949,523	1,186,281	±	3,948,961	0.0002	1,588,726	±	4,763,702	1,401,366	±	4,551,758	0.0604
70-79	787,351	±	2,726,490	1,109,054	±	3,604,815	<.0001	1,335,377	±	4,297,010	1,112,411	±	3,715,192	<.0001
80-89	633,244	±	2,300,431	2,187,746	±	5,123,806	<.0001	1,231,903	±	4,025,393	2,054,372	±	5,199,691	<.0001
90+	729,109	±	2,425,431	5,856,231	±	7,067,788	<.0001	1,538,128	±	4,709,164	5,886,268	±	7,243,645	<.0001
Insurance type														
Local subscriber	764,367	±	2,760,354	1,660,852	±	4,543,576	<.0001	1,250,140	±	4,145,829	1,929,664	±	5,124,829	<.0001
Employee covered	643,068	±	2,434,913	1,301,232	±	4,052,596	<.0001	1,167,008	±	4,086,649	1,451,752	±	4,357,670	<.0001
Medical aid	1,524,533	±	3,658,001	2,617,353	±	5,172,775	<.0001	1,995,147	±	4,741,304	3,031,983	±	5,937,287	<.0001
Region														
Metropolitan area	690,863	±	2,597,163	1,028,136	±	3,629,766	<.0001	1,134,127	±	4,020,263	1,179,948	±	4,010,514	0.2408
Non-metropolitan area	854,315	±	2,800,746	1,887,857	±	4,722,068	<.0001	1,418,271	±	4,325,715	2,158,638	±	5,234,317	<.0001
Income level														
Q1 (low)	1,177,064	±	3,374,760	2,284,136	±	5,061,704	<.0001	1,711,173	±	4,666,292	2,680,663	±	5,747,454	<.0001
Q2	705,959	±	2,593,005	1,453,821	±	4,412,932	<.0001	1,183,410	±	3,872,808	1,662,325	±	4,584,147	<.0001

Q3	722,601	±	2,677,642	1,404,212	±	4,088,347	<.0001	1,146,234	±	3,859,745	1,600,701	±	4,673,989	<.0001
Q4 (high)	601,091	±	2,263,457	1,199,762	±	3,896,408	<.0001	1,124,294	±	4,078,565	1,312,475	±	4,178,735	<.0001
Disability														
None	729,722	±	2,614,830	1,368,362	±	4,006,573	<.0001	1,224,983	±	4,005,177	1,575,156	±	4,411,637	<.0001
Severe	1,509,643	±	3,846,088	6,406,711	±	8,835,964	<.0001	2,716,076	±	7,100,552	6,272,184	±	9,153,909	<.0001
Mild	1,017,578	±	3,074,017	1,782,172	±	4,589,870	<.0001	1,457,754	±	4,459,846	1,800,642	±	4,877,895	<.0001
CCI (Charlson comorbidity index)														
0	320,684	±	1,394,622	507,425	±	2,203,435	0.0011	1,094,752	±	3,739,650	709,278	±	2,693,421	0.0042
1	568,810	±	2,307,427	1,768,133	±	4,502,809	<.0001	1,022,553	±	3,804,388	2,049,305	±	4,944,548	<.0001
2	629,196	±	2,339,251	1,429,084	±	3,983,425	<.0001	1,270,675	±	4,114,374	1,688,211	±	4,534,976	<.0001
3	780,797	±	2,634,106	1,439,246	±	4,222,616	<.0001	1,319,368	±	4,276,157	1,691,749	±	4,873,651	<.0001
4+	1,292,220	±	3,567,329	2,045,103	±	5,288,775	<.0001	1,691,156	±	4,703,313	2,142,641	±	5,618,133	<.0001

Appendix6. Changes in total healthcare expenditure before and after the introduction of the Cognitive Assistance Grade (Continued)

Variables	Pre-intervention period							Post-intervention period						
	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*	Case (Cognitive Assistance Grade)			Control (grade-excluded)			*P-value*
	Mean	±	SD	Mean	±	SD		Mean	±	SD	Mean	±	SD	
Total	1,445,585	±	2,861,704	2,190,298	±	4,363,446		1,941,472	±	4,276,360	2,475,287	±	4,831,266	
Gender														
Male	1,910,286	±	3,552,243	2,168,173	±	4,264,112	<.0001	2,252,075	±	4,687,143	2,540,407	±	5,147,043	<.0001
Female	1,322,009	±	2,634,219	2,196,169	±	4,389,456	<.0001	1,858,875	±	4,156,453	2,458,008	±	4,743,863	<.0001
Age														
70-	2,028,357	±	4,003,901	1,809,040	±	4,096,257	0.0017	2,192,230	±	4,783,105	2,047,368	±	4,703,480	0.1535
70-79	1,498,970	±	2,895,028	1,815,138	±	3,701,236	<.0001	2,050,496	±	4,397,315	1,935,433	±	3,859,600	0.0065
80-89	1,253,939	±	2,443,248	2,732,354	±	5,033,970	<.0001	1,834,430	±	4,078,246	2,684,414	±	5,163,905	<.0001
90+	1,191,097	±	2,505,517	6,135,044	±	6,882,473	<.0001	1,992,925	±	4,722,073	6,208,320	±	7,029,264	<.0001
Insurance type														
Local subscriber	1,389,302	±	2,883,665	2,269,803	±	4,567,557	<.0001	1,859,810	±	4,238,919	2,602,289	±	5,124,233	<.0001
Employee covered	1,253,144	±	2,599,551	1,917,981	±	4,081,156	<.0001	1,748,258	±	4,155,233	2,121,112	±	4,405,293	<.0001
Medical aid	2,438,152	±	3,667,105	3,369,500	±	5,040,024	<.0001	2,890,166	±	4,694,479	3,867,281	±	5,772,667	<.0001
Region														
Metropolitan area	1,327,117	±	2,731,093	1,680,286	±	3,760,422	<.0001	1,760,929	±	4,121,629	1,903,162	±	4,157,827	0.0004
Non-metropolitan area	1,520,484	±	2,938,867	2,507,413	±	4,671,605	<.0001	2,056,473	±	4,368,237	2,831,352	±	5,174,819	<.0001
Income level														
Q1 (low)	1,946,883	±	3,480,697	2,971,481	±	5,029,520	<.0001	2,448,177	±	4,686,773	3,436,124	±	5,673,115	<.0001
Q2	1,293,716	±	2,725,205	2,064,071	±	4,419,921	<.0001	1,741,687	±	3,911,306	2,329,867	±	4,588,657	<.0001

Q3	1,313,155	±	2,811,706	2,017,844	±	4,114,067	<.0001	1,708,396	±	3,915,435	2,235,322	±	4,668,732	<.0001
Q4 (high)	1,226,772	±	2,419,625	1,810,928	±	3,919,035	<.0001	1,734,972	±	4,177,694	1,992,873	±	4,248,037	<.0001
Disability														
None	1,355,410	±	2,751,108	1,971,666	±	3,989,062	<.0001	1,817,428	±	4,055,722	2,239,304	±	4,412,522	<.0001
Severe	2,358,136	±	3,948,524	7,410,579	±	9,009,353	<.0001	3,786,154	±	7,306,411	7,196,464	±	9,086,218	<.0001
Mild	1,790,725	±	3,202,021	2,499,798	±	4,588,210	<.0001	2,207,315	±	4,515,518	2,573,423	±	4,881,982	<.0001
CCI (Charlson comorbidity index)														
0	764,090	±	1,533,954	934,935	±	2,259,055	0.0055	1,594,802	±	3,756,067	1,242,037	±	2,828,512	0.0093
1	1,025,615	±	2,353,961	2,243,864	±	4,416,442	<.0001	1,496,780	±	3,822,418	2,584,616	±	4,861,986	<.0001
2	1,197,570	±	2,415,024	2,006,986	±	3,927,822	<.0001	1,820,836	±	4,142,075	2,333,642	±	4,500,479	<.0001
3	1,496,838	±	2,809,214	2,155,274	±	4,262,197	<.0001	1,993,231	±	4,356,071	2,466,150	±	4,954,123	<.0001
4+	2,249,060	±	3,728,295	2,970,172	±	5,373,751	<.0001	2,591,700	±	4,798,652	3,099,110	±	5,647,079	<.0001

Appendix7. Results of the difference-in-differences analysis of healthcare service utilization (Continued)

Variables	Number of outpatient visits				Inpatient length of stay			
	β	exp(β)	SE	*P-value*	β	exp(β)	SE	*P-value*
Wave (6 months)	-0.0061	0.994	0.0002	<.0001	0.0109	1.011	0.0008	<.0001
Policy								
Pre-intervention	Ref				Ref			
Post-intervention	0.0628	1.065	0.0062	<.0001	-0.1601	0.852	0.0158	<.0001
Control (non-graded)	Ref				Ref			
Case (Cognitive Assistance Grade)	-0.1217	0.885	0.0106	<.0001	-0.7446	0.475	0.0415	<.0001
Case*Policy	-0.0593	0.942	0.0072	<.0001	0.1815	1.199	0.0305	<.0001
Gender								
Male	Ref				Ref			
Female	0.0029	1.003	0.0131	0.8276	-0.277	0.758	0.0472	<.0001
Age								
70-	Ref				Ref			
70-79	0.2942	1.342	0.0112	<.0001	0.192	1.212	0.0366	<.0001
80-89	0.2759	1.318	0.0116	<.0001	0.4469	1.563	0.04	<.0001
90+	0.1478	1.159	0.0184	<.0001	0.701	2.016	0.0599	<.0001
Insurance type								
Local subscriber	Ref				Ref			
Employee covered	0.0069	1.007	0.0073	0.3428	-0.0526	0.949	0.0305	0.0839
Medical aid	0.152	1.164	0.0147	<.0001	0.537	1.711	0.0608	<.0001
Region								

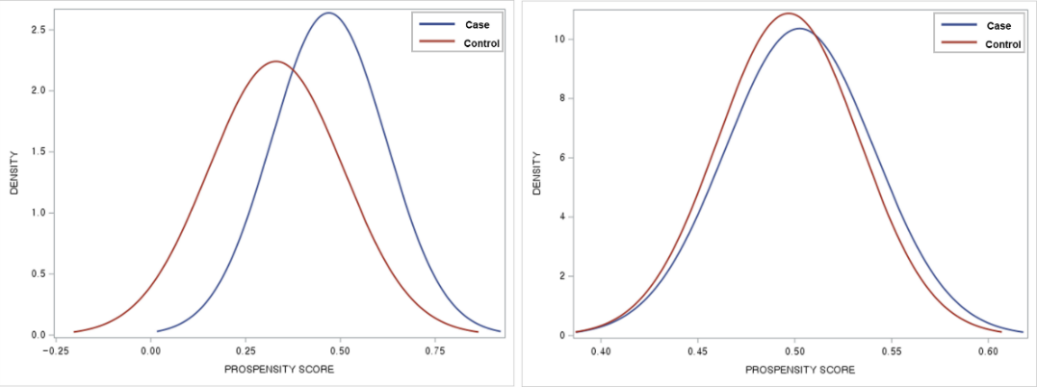
Metropolitan area	Ref				Ref			
Non-metropolitan area	0.1048	1.110	0.0091	<.0001	0.4106	1.508	0.0402	<.0001
Income level								
Q1 (low)	Ref				Ref			
Q2	0.0048	1.005	0.0084	0.5658	-0.0755	0.927	0.0344	0.0280
Q3	-0.0053	0.995	0.0085	0.5316	-0.0897	0.914	0.0363	0.0134
Q4 (high)	-0.0029	0.997	0.0084	0.7327	-0.1991	0.819	0.0347	<.0001
Disability								
None	Ref				Ref			
Severe	0.0688	1.071	0.0245	0.0049	0.6791	1.972	0.0953	<.0001
Mild	0.1523	1.165	0.0111	<.0001	0.2751	1.317	0.0425	<.0001
CCI (Charlson comorbidity index)								
0	Ref				Ref			
1	-0.0053	0.995	0.0259	0.8391	1.2117	3.359	0.1216	<.0001
2	0.1886	1.208	0.0256	<.0001	1.0383	2.824	0.1219	<.0001
3	0.3712	1.449	0.026	<.0001	0.9609	2.614	0.1243	<.0001
4+	0.5636	1.757	0.0256	<.0001	1.1846	3.269	0.1213	<.0001

Appendix8. Results of the difference-in-differences analysis of healthcare expenditure (Continued)

Variables	Outpatient healthcare expenditure				Inpatient healthcare expenditure				Total healthcare expenditure			
	β	exp(β)	SE	*P-value*	β	exp(β)	SE	*P-value*	β	exp(β)	SE	*P-value*
Wave (6 months)	0.0027	1.0027	0.0003	<.0001	0.0107	1.0108	0.0009	<.0001	0.0077	1.0077	0.0005	<.0001
Policy												
Pre-intervention	Ref				Ref				Ref			
Post-intervention	0.0083	1.0083	0.0101	0.4075	-0.2079	0.8123	0.0267	<.0001	-0.1174	0.8892	0.0163	<.0001
Control (non-graded)	Ref				Ref				Ref			
Case (Cognitive Assistance Grade)	-0.0205	0.9797	0.0111	0.0655	-0.5741	0.5632	0.0317	<.0001	-0.3817	0.6827	0.0196	<.0001
Case*Policy	-0.1085	0.8972	0.0102	<.0001	0.2730	1.3139	0.0306	<.0001	0.0953	1.1000	0.0187	<.0001
Gender												
Male	Ref				Ref				Ref			
Female	-0.0689	0.9334	0.0142	<.0001	-0.1649	0.8480	0.0331	<.0001	-0.1068	0.8987	0.0214	<.0001
Age												
70-	Ref				Ref				Ref			
70-79	0.2563	1.2921	0.0153	<.0001	0.0286	1.029	0.0415	0.4899	0.1325	1.1417	0.0263	<.0001
80-89	0.1389	1.1490	0.0160	<.0001	0.3005	1.3505	0.0430	<.0001	0.2662	1.305	0.0275	<.0001
90+	-0.1651	0.8478	0.0261	<.0001	0.8244	2.2805	0.0611	<.0001	0.6214	1.8615	0.0444	<.0001
Insurance type												
Local subscriber	Ref				Ref				Ref			
Employee covered	0.0020	1.0020	0.0099	0.8383	-0.0531	0.9483	0.0278	0.0564	-0.0411	0.9597	0.0175	0.0191
Medical aid	0.2331	1.2625	0.0183	<.0001	0.3804	1.4629	0.0430	<.0001	0.3292	1.3899	0.0286	<.0001
Region												

Metropolitan area	Ref				Ref				Ref			
Non-metropolitan area	-0.0277	0.9727	0.0107	0.0094	0.3263	1.3858	0.0278	<.0001	0.2109	1.2348	0.0174	<.0001
Income level												
Q1 (low)	Ref				Ref				Ref			
Q2	-0.0228	0.9775	0.0137	0.0954	-0.1231	0.8842	0.0354	0.0005	-0.0867	0.9170	0.0229	0.0001
Q3	-0.0262	0.9741	0.0138	0.0583	-0.1258	0.8818	0.0356	0.0004	-0.0973	0.9073	0.0228	<.0001
Q4 (high)	-0.0031	0.9969	0.0130	0.8110	-0.2613	0.7700	0.0330	<.0001	-0.1682	0.8452	0.021	<.0001
Disability												
None	Ref				Ref				Ref			
Severe	0.2878	1.3335	0.0558	<.0001	0.9358	2.5493	0.0717	<.0001	0.7654	2.1499	0.0518	<.0001
Mild	0.1576	1.1707	0.0125	<.0001	0.1958	1.2163	0.0322	<.0001	0.1786	1.1955	0.0209	<.0001
CCI (Charlson comorbidity index)												
0	Ref				Ref				Ref			
1	0.042	1.0429	0.0251	0.0943	0.8180	2.266	0.0772	<.0001	0.5485	1.7307	0.0447	<.0001
2	0.2134	1.2379	0.0248	<.0001	0.7910	2.2056	0.0765	<.0001	0.5792	1.7846	0.0436	<.0001
3	0.4045	1.4986	0.0269	<.0001	0.8408	2.3182	0.0780	<.0001	0.669	1.9523	0.0445	<.0001
4+	0.6401	1.8967	0.0258	<.0001	1.1618	3.1957	0.0755	<.0001	0.9535	2.5948	0.043	<.0001

Appendix9. Kernel density comparison of propensity scores for cognitive and physical function analysis.



Appendix10. Comparison of case and control group characteristics before and after matching for cognitive and physical functions analysis

Variable	Before Matching					After Matching				
	Case (Cognitive Assistance Grade)		Control (grade-excluded)		SMD	Case (Cognitive Assistance Grade)		Control (grade-excluded)		SMD
	Mean	SD	Mean	SD		Mean	SD	Mean	SD	
Age	81.48	6.44	78.37	6.88	0.4667	81.21	6.35	80.41	6.31	0.1264
Cognitive Function Score	40.14	15.61	32.64	14.39	0.4996	37.82	14.05	35.98	14.61	0.1284

*SMD: standardized mean differences

Appendix11.Comparison of case and control group characteristics before and after matching for cognitive and physical functions analysis

Variable	Before Matching					After Matching				
	Case		Control		SMD	Case		Control		SMD
	N (Mean)	%(SD)	N (Mean)	%(SD)		N (Mean)	%(SD)	N (Mean)	%(SD)	
Obs.	14,261	100.00	13,705	100.00		2,829	100.00	2,105	100.00	
Cognitive Function Score	40.72	16.01	32.56	15.17	0.5232	36.09	14.03	35.37	15.89	0.0475
Grade Maintenance Period	346.53	249.70	731.93	683.70	0.7488	388.33	277.93	398.27	334.18	0.0323
Gender										
Male	3,641	25.53	5,078	37.05	0.2521	897	31.71	679	32.26	0.0118
Female	10,620	74.47	8,627	62.95	0.2521	1,932	68.29	1,426	67.74	0.0118
Age										
70-	775	5.43	1,691	12.34	0.2448	212	7.49	182	8.65	0.0423
70-79	3,928	27.54	5,238	38.22	0.2293	927	32.77	699	33.21	0.0093
80-89	8,406	58.94	6,298	45.95	0.2605	1,546	54.65	1,125	53.44	0.0242
90+	1,152	8.08	478	3.49	0.1978	144	5.09	99	4.70	0.0179
Disability										
None	10,636	74.58	9,212	67.22	0.1635	2,081	73.56	1,532	72.78	0.0176
Severe	571	4.00	1,182	8.62	0.1902	131	4.63	148	7.03	0.1026
Mild	3,054	21.42	3,311	24.16	0.0668	617	21.81	425	20.19	0.0398

*SMD: standardized mean differences

Appendix12. General characteristics of study participants (Continued)

Variables	Baseline				P-value
	Case (Cognitive Assistance Grade)		Control (grade-excluded)		
	N	%	N	%	
Total	2,829	100	2,105	100.0	
Gender					
Male	897	31.71	679	32.3	0.6824
Female	1,932	68.29	1,426	67.7	
Age					
70-	212	7.49	182	8.6	0.4288
70-79	927	32.8	699	33.2	
80-89	1,546	54.6	1,125	53.4	
90+	144	5.1	99	4.7	
Insurance type					
Local subscriber	692	24.5	547	26.0	0.1121
Employee covered	1,373	48.5	1,043	49.5	
Medical aid	764	27.0	515	24.5	
Region					
Metropolitan area	881	31.1	678	32.2	0.4251
Non-metropolitan area	1,948	68.9	1,427	67.8	
Income level					
Q1 (low)	1,174	41.5	844	40.1	0.5714
Q2	323	11.4	265	12.6	
Q3	435	15.4	328	15.6	
Q4 (high)	897	31.7	668	31.7	
Presence of caregiver					
Yes	2,210	78.1	1,595	75.8	0.0522
No	619	21.9	510	24.2	
Living alone					
Yes	1,512	53.4	1,134	53.9	0.7670
No	1,317	46.6	971	46.1	

Disability					
None	2,081	73.6	1,532	72.8	
Severe	131	4.6	148	7.0	0.0010
Mild	617	21.8	425	20.2	
CCI (Charlson comorbidity index)					
0	382	13.5	292	13.9	
1	597	21.1	450	21.4	
2	570	20.1	417	19.8	0.9681
3	439	15.5	314	14.9	
4+	841	29.7	632	30.0	

Appendix13. Results of the difference-in-differences analysis of cognitive and physical function (Continued)

Variables	Cognitive Function Score				Physical Function Score (Activities of Daily Living Score)			
	β	exp(β)	SE	*P-value*	β	exp(β)	SE	*P-value*
Wave (3 months)	0.0088	1.0088	0.0004	<.0001	0.0182	1.0184	0.0005	<.0001
Grade maintenance period (100day units)	-0.0064	0.9936	0.0019	0.0009	-0.025	0.9753	0.0015	<.0001
Policy								
Pre-intervention	Ref				Ref			
Post-intervention	0.1678	1.1827	0.0399	<.0001	-0.2017	0.8173	0.0331	<.0001
Control (grade-excluded)	Ref				Ref			
Case (Cognitive Assistance Grade)	0.3083	1.3611	0.0395	<.0001	-0.1469	0.8634	0.0324	<.0001
Case*Policy	-0.1572	0.8545	0.04	<.0001	-0.0124	0.9877	0.0334	0.7096
Gender								
Male	Ref				Ref			
Female	0.0974	1.1023	0.01	<.0001	0.0115	1.0116	0.0079	0.1461
Age								
70-	Ref				Ref			
70-79	0.011	1.0111	0.0182	0.5446	0.0333	1.0339	0.0132	0.0112
80-89	0.0554	1.0570	0.018	0.002	0.0446	1.0456	0.0127	0.0005
90+	0.1382	1.1482	0.0237	<.0001	0.0536	1.0551	0.0191	0.005
Insurance type								
Local subscriber	Ref				Ref			
Employee covered	-0.0053	0.9947	0.0109	0.6289	0.0322	1.0327	0.0095	0.0007

Medical aid	-0.0383	0.9624	0.0142	0.0072	0.0036	1.0036	0.0117	0.7583
Region						1.0000		
Metropolitan area	Ref				Ref			
Non-metropolitan area	-0.0382	0.9625	0.0097	<.0001	-0.0127	0.9874	0.0078	0.1024
Income level								
Q1 (low)	Ref				Ref			
Q2	-0.0069	0.9931	0.0145	0.6331	-0.0243	0.9760	0.014	0.0833
Q3	-0.0121	0.9880	0.0145	0.4023	-0.0154	0.9847	0.0134	0.2496
Q4 (high)	-0.0268	0.9736	0.0134	0.0461	-0.0101	0.9900	0.0121	0.4024
Presence of caregiver								
Yes	Ref				Ref			
No	0.0513	1.0526	0.0092	<.0001	0.076	1.0790	0.0083	<.0001
Living alone								
Yes	Ref				Ref			
No	0.0532	1.0546	0.0086	<.0001	0.0876	1.0916	0.0081	<.0001
Disability								
None	Ref				Ref			
Severe	0.0747	1.0776	0.0216	0.0005	-0.0163	0.9838	0.0148	0.2685
Mild	-0.0112	0.9889	0.0108	0.3014	-0.0078	0.9922	0.0084	0.3497
CCI (Charlson comorbidity index)								
0	Ref				Ref			
1	-0.0034	0.9966	0.0154	0.824	0.0024	1.0024	0.0122	0.8414
2	-0.0129	0.9872	0.0155	0.4081	0.0156	1.0157	0.0124	0.2075

3	-0.0245	0.9758	0.0169	0.1464	0.0167	1.0168	0.0134	0.2105
4+	-0.0335	0.9671	0.0149	0.0242	0.0362	1.0369	0.0118	0.0022

Abstract in Korean

장기요양 인지지원등급 신설이 치매 노인의 건강 결과에 미치는 영향

서론: 전 세계적으로 고령화가 가속화됨에 따라 인지 기능 관리와 치매 치료의 경제적 부담을 해결하는 것이 중요한 과제로 부각되고 있다. 한국은 2018 년 1 월, 노인의 인지기능 저하를 늦추고 의료 서비스 결과를 개선하기 위해 노인장기요양보험에 인지지원등급을 도입하였다. 본 연구는 인지지원등급 정책이 치매 환자의 인지기능 및 신체기능에 미치는 영향을 분석함으로써 해당 정책의 효과를 평가하고자 한다.

연구방법: 본 연구는 국민건강보험공단의 국민건강정보 데이터베이스를 활용하여 총 6,265 명의 데이터를 분석에 포함하였다. 준실험적 설계를 통해 2014 년부터 2024 년 6 월까지의 전국 데이터를 분석하였다. 인지지원등급 수혜자와 비수혜자의 결과를 비교하기 위해 성향점수매칭(PSM)과 이중차분법(DID) 분석을 적용하였다. 인지지원등급 판정 이후 정책의 수혜를 받게 된 4,099 명을 연구의 사례군으로 선정하였고, 등급판정을 신청하였으나 등급외로 판정되어 정책의 수혜를 받지 못하는 2,166 명을 매칭을 통해 대조군으로 선정하였다. 종속변수는 인지기능점수와 신체기능점수로, 두 점수는 모두 장기요양인정 점수 측정 환산표에 따라 0 에서 100 점 사이로 변환되었으며, 점수가 높을수록 기능에 더 악화되었음을 의미한다. 정책 도입에 따른 인지기능 및 신체기능 변화를 분석하기 위해 인지지원등급과 등급외로 판정된 시점을 기준월(index month)로 하여 기준월 이전 24 개월과 기준월 이후 24 개월, 총 48 개월의 변화를 분석하였다. 데이터 분포의 비대칭성을 처리하고 잠재적 교란 요인을 통제하기 위해 일반화 추정 방정식(GEE)과 로그 링크 함수(log−link function)를 활용한 음이항 회귀 등 통계 모델을 사용하였다.

연구결과: 인지지원등급 정책 도입 전, 후 평균 인지기능 점수는 사례군에서 각각 34.55 점과 41.91 점으로 나타났으며, 대조군에서는 각각 25.88 점과 35.63 점으로 양쪽 그룹 모두 점수가 증가하였다. 인지지원등급 정책 도입 전, 후 평균 신체기능 점수는 사례군에서 각각 15.57 점과 17.47 점으로 증가하였으며, 대조군에서는 각각 17.11 점과 19.66 점으로 나타났다. 이중차분법 분석 결과, 인지지원등급은 비수혜자에 비해 수혜자의 인지 기능 저하를 유의하게 지연시키는 것으로 확인되었다($\beta = -0.1564$, $\exp(\beta) = 0.8552$, $p < 0.0001$). 그러나 신체 기능에서는 통계적으로 유의미한 차이가 관찰되지 않았다($\beta = 0.0356$, $\exp(\beta) = 1.0362$, $p = 0.2313$).

결론: 인지지원등급 정책은 치매 환자의 인지기능 저하를 효과적으로 늦춰 치매 예방 치료에서 그 중요성을 강조한다. 그러나 신체 기능에는 큰 영향을 미치지 못한다는 점은 신체 활동과 재활을 위한 맞춤형 개입의 필요성을 시사한다. 이러한 연구 결과는 예방적 치매 치료 프로그램에 대한 보다 광범위하고 공평한 접근을 보장하기 위한 정책 확대의 필요성을 뒷받침하는 근거를 제공한다.

핵심되는 말: 인지지원등급, 치매 정책 평가, 인지기능 저하 예방, 고령 인구