

# The Economic Burden of Brain Disability in Korea, 2008-2011

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Hyun-Jin Kim, PhD<sup>1</sup>, Seung Hee Ho, PhD<sup>2</sup>, Sol Lee, MPH<sup>2</sup>,  
In-Hwan Oh, MD, PhD<sup>3</sup>, Ju Hee Kim, MPH<sup>2</sup>, Eun Joo Kim, MD<sup>4</sup>,  
and Seong Jae Lee, MD, PhD<sup>5</sup>

## Abstract

This study estimated the economic burden of people with brain disability in Korea during 2008-2011 using nationally representative data and was conducted to use the results as an evidence for determining the resources allocation of people with brain disability. We used a prevalence-based approach to estimate the economic burden, classified by direct costs (medical costs and nonmedical costs) and indirect costs (productivity loss of morbidity and premature death). Data from the National Health Insurance Service, the National Disability Registry, the National survey on persons with disabilities, the Korea National Statistical Office's records of causes of death, and the Labor Statistics were used to calculate direct and indirect costs. The treated prevalence of brain disability increased from 0.26% (2008) to 0.35% (2011). Total economic burden of brain-related diseases was US\$1.88 billion in 2008 and increased to US\$2.90 billion in 2011, with a 54% rate of increase. The economic burden of all diseases, which was 1.2 to 1.4 times higher than that of brain-related diseases, accounted for US\$2.61 billion in 2008 and US\$3.62 billion in 2011, increasing by 39%. Owing to the growing occurrence of brain disability, the annual prevalence and related costs are increasing. Health management programs are necessary to reduce the economic burden of brain disability in Korea.

## Keywords

brain disease, disabled persons, cost of illness, Korea

### What do we already know about this topic?

In 2013, 2 501 112 Koreans were classified as disabled, indicating that 5% of the whole population in Korea had some form of disability. Among them, People with Brain Disabilities (PWBD) totaled 253 493, accounting for 10.13% of the all disabled. Brain disorders also impose a huge economic burden not only owing to the costs of treatment, but also to the lost productivity of patients and caregivers, including continuous care provided by family members. In Europe, the European Brain Council (EBC) estimated the economic cost of brain disorders in 2004, and the total cost for Europe was US\$535.24 billion (€386 billion) for 2004 and US\$1106.5 billion (€798 billion) for 2010, increasing by 2 times. Although brain disability represented a huge economic burden, in Korea, it was difficult to find studies estimating the economic burden of registered persons with brain disability, other than studies of economic burden focused on single diseases, such as stroke, cancer, and asthma. Thus, the objective of this study was to estimate the economic burden of PWBD using nationally representative data such as the National Health Insurance Service (NHIS), the NDR of Ministry of Health and Welfare (MOHW), the National Statistical Office (NSO) records of cause of death and investigate the cost changes between 2008 and 2011 in Korea.

### How does your research contribute to the field?

This study estimated the social-economic burden of PWBD and identified the difference of economic cost depending on gender, age, and cost items. We are expecting our study to be a fundamental evidence for people who are giving a treatment to PWBD based on early intervention and prevention.

### What are your research's implications toward theory, practice, or policy?

This study estimated the treated prevalence and economic burden of PWBD for the first time from 2008 to 2011 using nationally representative data. The economic burden of people with brain disability is substantial, which has been increasing steadily each year. These objective data can be used as the basis of establishing and evaluating the health management policy. Thus, to reduce the economic burden of people with brain disability, it is necessary to prevent the primary diseases and to have early concentrated treatment and rehabilitation therapy to minimize disability. In addition, health management policy is needed to prevent secondary diseases, which are comorbid with the primary disability.



## Introduction

In 2013, 2 501 112 Koreans were classified as disabled, indicating that 5% of the whole population in Korea had some form of disability. Among them, People With Brain Disabilities (PWBD) totaled 253 493, accounting for 10.13% of the all disabled.<sup>1</sup> In Korea, the National Disability Registry (NDR), which covers 91.7% of the total population, registers people with disability through local government.<sup>2</sup> According to the Registered Disabled Persons from the Korean Statistical Information Service, the third leading disability was brain disability, followed by physical and auditory disability.<sup>1</sup> In Korea, brain disorders due to organic lesion of the brain, such as stroke, cerebral palsy, and traumatic brain injury (TBI), mostly limit activities of daily living and ambulation, showing signs of paralysis of upper and lower limbs, and are accompanied by language and visual disorder.<sup>3</sup>

Brain disorders also impose a huge economic burden not only owing to the costs of treatment, but also to the lost productivity of patients and caregivers, including continuous care provided by family members.<sup>4,5</sup>

In a study of the burden of disease in Europe, 23% of Years of Life Lost due to premature mortality and 50% of Years Lived with Disability (YLD) were caused by brain diseases, and 35% of the burden of all diseases resulted from brain diseases.<sup>5</sup> In Spain, in 2008, 1.5 million Disability-Adjusted Life Years (DALYs) were due to brain disorders. The great majority of the burden of disease was due to YLD (93.1% of the total DALYs).<sup>4</sup>

The Cost-Of-Illness (COI) study for diseases with high mortality rate and huge socioeconomic burden was performed to effectively prevent diseases and to determine the priorities of the nation's health policy. Estimating the economic burden of diseases is necessary for policy makers and public health researchers. The COI study can evaluate the distribution of health care service and explain the level of health of all people, comparing the outcomes of health care service systems.<sup>6</sup>

In Europe, the European Brain Council (EBC) estimated the economic cost of brain disorders in 2004, including mental disorders and neurological disorders in 30 European countries and updated the study using recent epidemiologic data and cost resources in 2010. The total cost for Europe was US\$535.24 billion (€386 billion) for 2004 and US\$1106.5 billion (€798 billion) for 2010, increasing

by 2 times. Direct medical costs accounted for 37% of the total costs of brain disorders, whereas direct nonmedical costs represented 23% and indirect costs represented 40%. Societal costs of stroke totaled US\$75.02 billion (€54.1 billion), whereas TBI totaled US\$45.76 billion (€33.0 billion).<sup>7</sup>

Although brain disability represented a huge economic burden, in Korea, it was difficult to find studies estimating the economic burden of registered persons with brain disability, other than studies of economic burden focused on single diseases, such as stroke, cancer, and asthma.<sup>8-10</sup>

Thus, the objective of this study was to estimate the economic burden of PWBD using nationally representative data such as the National Health Insurance Service (NHIS), the NDR of Ministry of Health and Welfare (MOHW), the National Statistical Office (NSO) records of cause of death and investigate the cost changes between 2008 and 2011 in Korea.

## Methods

To measure economic costs, we merged data from the NDR of MOHW with claims data from NHIS by year from 2008 to 2011. The NDR database includes social security numbers and information associated with disability, such as disability type and degree of disability. There are 15 types of disability and the degree of disability ranges from grade 1 to grade 6 by type severe to mild. Medical specialists, based on functional limitation and clinical disability, diagnose the type and degree of disability.<sup>11</sup> The PWBD's personal identification number linked to the health care utilization data of NHIS is deleted before analysis.

The present study estimated the economic burden of PWBD using a prevalence-based approach. The diseases of brain disability were 23 classifications of the 298 in the *International Classification of Diseases, 10th Revision (ICD-10)*<sup>12</sup> (Supplemental Appendix 1) including cerebrovascular diseases, cerebral palsy, head injuries, other disorders of the nervous system, sequelae of injuries, transport accidents, and so on.

Two methods were used to estimate the cost of PWBD. First, we calculated the economic burden of PWBD as the burden attributable to those with a primary diagnosis of brain-related disease among the PWBD data from 2008 to 2011. Second, we estimated the economic burden of PWBD

<sup>1</sup>Department of Clinical Research for Rehabilitation, Korea National Rehabilitation Research Institute, Seoul, South Korea

<sup>2</sup>Department of Healthcare and Public Health Research, Korea National Rehabilitation Research Institute, Seoul, South Korea

<sup>3</sup>Department of Preventive Medicine, Kyung Hee University School of Medicine, Seoul, South Korea

<sup>4</sup>Department of Community Reintegration Service, Korea National Rehabilitation Hospital, Seoul, South Korea

<sup>5</sup>Department of Rehabilitation Medicine, College of Medicine, Dankook University, Cheonan, South Korea

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### Corresponding Author:

Seung Hee Ho, Department of Healthcare and Public Health Research, Korea National Rehabilitation Research Institute, 58 Samgaksan-ro, Gangbuk-gu, Seoul 01022, South Korea.

Email: hsh7@korea.kr

by applying health care service uses due to all diseases including brain-related diseases between 2008 and 2011.

The economic burden was classified into direct and indirect costs. The direct costs consisted of direct medical costs, including medical services, as well as *selective medical treatment and assistive devices*, costs of meals, non-NHIC-covered care costs, and *direct nonmedical costs including transportation and nursing costs*.<sup>8</sup>

To calculate direct medical costs, we used the costs of treatment of diseases related to brain disability and all diseases from NHIS claims data in 2008-2011. Korea's health insurance system is a mandatory universal health system, which is operated by a single public insurer. Thus, the NHIS claims data are representative of the medical expenses for the entire Korean population.<sup>13</sup> However, health claims data include only those who were available for health care access, which may result in selection bias. Also, the bias, such as errors of health claims data and overcharge for medical services, may occur in the course of charging outpatient visits for brain disability.<sup>14</sup>

The non-NHIC-covered costs, paid by patients, consisted of costs of meals, fees for elective services, and differences on costs due to the use of private wards.<sup>8</sup> However, the non-NHIC-covered care costs were not included in the claims data in the Korean health insurance system. Thus, we applied the coverage rate of non-NHIC-covered care costs as 12% of that of a national rehabilitation hospital in Korea. The cost of purchasing and maintaining assistive devices was obtained from survey data relating to 118 PWBD of institutions for the disabled. The person in charge of institutions recruited those surveyed and the surveyors, and the person in charge of each institution performed the surveys directly. To ensure equal regional distribution, we requested cooperation from the Association of the Disabled. Moreover, the Korean government supported registered persons with disabilities in purchasing assistive devices at reduced prices. Thus, we performed surveys to check whether the subjects were registered as disabled. The contents of the survey included type of assistive devices, annual purchase and repair cost, and change cycle of assistive devices. The cost of assistive devices was conducted by survey and this can be affected by recall bias. The disabled when asked about the cost of assistive devices through the retrospective survey might not recall the exact cost for the illness.<sup>14</sup> The cost of purchasing and maintaining assistive devices was US\$819.40.

The direct nonmedical costs were composed of transportation and nursing costs caused by hospitalization or outpatient visits for treatments of brain disability-related diseases and all diseases. The average cost of visiting hospitals used was US\$8.01 per 2-way trip for hospitalization and US\$2.74 per 2-way trip for outpatient visits, based on the survey results of the rehabilitation hospital and institution for the disabled. On the supposition that the disabled were accompanied by a guardian, we applied round trip fare for 2 persons. To calculating nursing costs, we used an inpatient cost for

one day of US\$48.38 and an outpatient cost for one day of US\$21.41 from the same transportation cost data. Nursing costs of outpatients were estimated by multiplying average nursing costs by one-third and the total number of outpatient visits. We assumed that the length of an outpatient visit is roughly one-third of daily working hours.<sup>13</sup>

Indirect costs, defined as the opportunity costs due to medical services of morbidity or premature death, were calculated as the cost of productivity loss based on the human capital approach.<sup>15</sup> Inpatient productivity loss costs were estimated by multiplying the days of hospitalization and the average wage. Outpatient productivity loss costs were estimated by multiplying the number of outpatient visits by the average time and the average wage. We estimated that the average time was defined 3 hours including time for transfer. And we assumed this value to be one-third of working hours. The average wage per day of brain disability from the 2011 National Survey on Persons with Disabilities (PWD) was used by age groups.<sup>2</sup> Because PWBD below 19 and above 70 years of age were considered not to participate in economic activity, we excluded productivity loss of PWBD in our estimation. To calculate the cost of premature death, the number of deaths of PWBD was totaled using the death data from NSO<sup>16</sup> and an annual discount rate of 3% was applied for the cost of premature death.<sup>8</sup>

$$IDC = \sum_{ag=2}^6 (AWag \times Fi, ag) + \sum_{ag=2}^6 (AWag \times Fo, ag \times \frac{1}{3}) + \sum_{ag=0}^6 (PAWag \times Fd, ag)$$

where *IDC* is the indirect cost; *AWag* is the average wage on a certain age group; *Fi, ag* is the frequency of inpatients per age group; *Fo, ag* is the frequency of outpatients per age group; *PAWag* is the present value of averaged wage on a certain age group; *Fd, ag* is the frequency of dead people per age group.

All costs were converted to 2011 US\$ (US\$1 = 1127.50 won).<sup>17</sup> We also calculated the economic burden by applying the consumer price index of the NSO by year.<sup>18</sup>

The sensitivity analysis was performed using 2 methods: application of a 5% discount rate and wages of the nondisabled to calculate indirect costs.<sup>19,20</sup>

## Results

The number of brain disability cases was 130 562 in 2008 and the treated-prevalence rate of brain disability was 0.26% in 2008, thereafter increasing annually through 2011 (0.35% in 2011). By gender, men had a higher treated-prevalence rate than women and the treated-prevalence rate of both men and women increased from 2008 to 2011. In terms of age group, both men and women in their 70s had the highest

**Table 1.** Prevalence of PWBD in Korea in 2008-2011.

Year	2008			2009			2010			2011		
	Age group	Male	Female	All	Male	Female	All	Male	Female	All	Male	Female
Brain-related diseases_treated prevalence, %												
0-9	0.12	0.09	0.11	0.13	0.10	0.11	0.12	0.10	0.11	0.13	0.10	0.11
10-19	0.05	0.04	0.04	0.06	0.04	0.05	0.07	0.05	0.06	0.07	0.06	0.07
20-29	0.04	0.02	0.03	0.04	0.02	0.03	0.05	0.03	0.04	0.04	0.03	0.03
30-39	0.06	0.03	0.04	0.06	0.03	0.05	0.07	0.03	0.05	0.06	0.03	0.05
40-49	0.18	0.08	0.13	0.18	0.08	0.13	0.18	0.08	0.13	0.17	0.08	0.13
50-59	0.57	0.29	0.43	0.59	0.30	0.45	0.61	0.30	0.45	0.60	0.28	0.44
60-69	1.27	0.82	1.03	1.37	0.85	1.10	1.46	0.88	1.16	1.45	0.86	1.14
70-79	1.65	1.27	1.42	1.97	1.48	1.68	2.23	1.64	1.87	2.42	1.74	2.02
80-89	1.06	0.87	0.93	1.47	1.17	1.26	1.85	1.48	1.59	2.25	1.71	1.87
90+	0.34	0.25	0.26	0.64	0.40	0.45	1.05	0.59	0.69	1.50	0.90	1.03
Total	0.30	0.23	0.26	0.34	0.26	0.30	0.38	0.29	0.33	0.40	0.31	0.35
All diseases_treated prevalence, %												
0-9	0.15	0.12	0.13	0.16	0.12	0.14	0.15	0.12	0.14	0.15	0.12	0.14
10-19	0.09	0.07	0.08	0.11	0.08	0.09	0.12	0.09	0.10	0.13	0.10	0.11
20-29	0.11	0.06	0.09	0.11	0.07	0.09	0.12	0.07	0.09	0.12	0.07	0.09
30-39	0.14	0.07	0.11	0.15	0.07	0.11	0.15	0.08	0.12	0.16	0.08	0.12
40-49	0.31	0.14	0.23	0.32	0.14	0.23	0.31	0.14	0.22	0.30	0.13	0.22
50-59	0.86	0.43	0.65	0.88	0.43	0.66	0.88	0.42	0.65	0.87	0.40	0.64
60-69	1.88	1.16	1.50	1.99	1.20	1.57	2.03	1.20	1.59	2.03	1.16	1.58
70-79	2.39	1.80	2.04	2.80	2.08	2.37	3.10	2.23	2.58	3.39	2.37	2.78
80-89	1.56	1.34	1.41	2.16	1.79	1.90	2.68	2.19	2.34	3.22	2.55	2.75
90+	0.53	0.42	0.45	1.02	0.72	0.79	1.57	1.11	1.21	2.26	1.61	1.75
Total	0.47	0.34	0.41	0.52	0.39	0.45	0.56	0.42	0.49	0.60	0.44	0.52

Note. PWBD = People with Brain Disabilities.

treated-prevalence rate, followed by those in their 80s, and those in their 60s between 2009 and 2011, except for 2008, and it showed that those above 60 had high treated-prevalence rates. The treated-prevalence rate of all diseases increased from 0.41% in 2008 to 0.52% in 2011, and the treated-prevalence rate of men was higher than that of women (Table 1).

The total economic burden of brain disability substantially increased from US\$1.88 billion (2008) to US\$2.90 billion (2011), explaining approximately 54% of the economic burden. The economic burden of all diseases grew by 39%, from US\$2.61 billion in 2008 to US\$3.62 billion in 2011, and was 1.2 to 1.4 more than the cost of brain-related diseases. By age group, in 2011, men in their 50s had the highest burden, followed by 60s, 40s, and 70s or older, and women in their 70s or older had the largest burden, followed by 60s and 50s, indicating differences according to gender and age groups. This result showed a similar tendency in the economic burden of all diseases (Table 2).

Regarding to the proportion of costs, direct medical costs accounted for 34.3% of the economic burden of brain disability, whereas direct nonmedical costs accounted for 12.1% and indirect costs accounted for 53.6% in 2008. In 2011, the proportions of costs were 44.2%, 15.7%, and 40.1%,

respectively, showing an increase in the direct costs ratio; on the contrary, the indirect costs ratio decreased between 2008 and 2011. The proportion of the economic burden of all diseases was 40.7% for direct medical costs, 15.0% for direct nonmedical costs, and 44.3% for indirect costs (Figure 1).

By gender, men had a 1.4 to 1.5 times greater burden than women. Regarding the proportion of cost items, the proportion of indirect costs for men was the highest, whereas direct medical costs for women were lower. For men, the economic burden of PWBD was US\$1.14 billion in 2008, US\$1.32 billion in 2009, US\$1.54 billion in 2010, and US\$1.70 billion in 2011, increasing from 2008 to 2011. The economic burden of all diseases for men, which was 1.2 to 1.4 greater times than that of brain-related diseases, increased between 2008 and 2011. The economic burden of women with brain disability was US\$0.74 billion in 2008, US\$0.88 billion in 2009, US\$1.06 billion in 2010, and US\$1.21 billion in 2011, representing a 61.2% increase over a 4-year period. The economic burden of all diseases increased annually and was 1.2 to 1.5 times higher than the cost of brain-related diseases (Table 3).

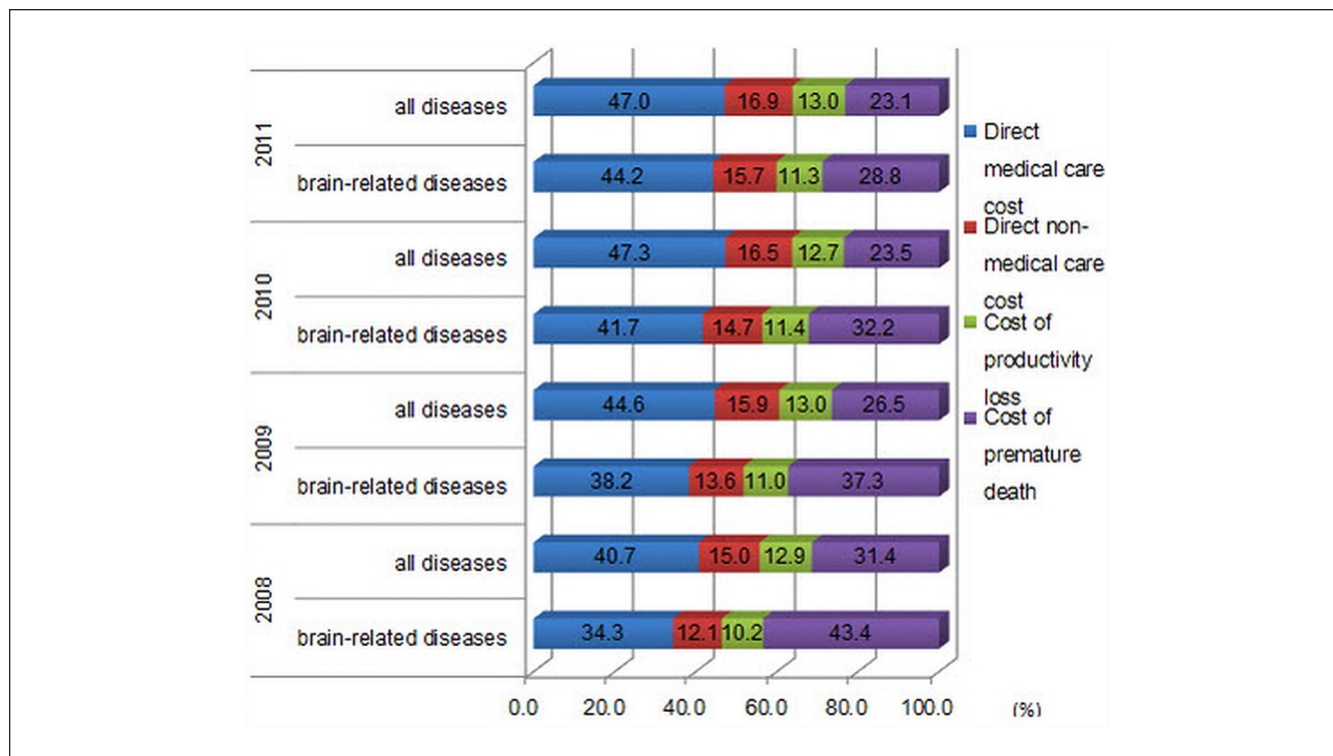
Two sensitivity analyses were performed: (1) applying 5% discount rate and (2) applying the wages of the nondisabled. First, the economic burden, with a 5% discount rate applied, was US\$1.77 billion in 2008 and US\$2.78 billion in

**Table 2.** Total Economic Burden of PWBD by Gender in 2008-2011.

Age of patients, y	2008		2009		2010		2011	
	Brain-related diseases <sup>a</sup>	All diseases <sup>a</sup>	Brain-related diseases <sup>a</sup>	All diseases <sup>a</sup>	Brain-related diseases <sup>a</sup>	All diseases <sup>a</sup>	Brain-related diseases <sup>a</sup>	All diseases <sup>a</sup>
<b>Male</b>								
0-19	62.9	82.3	65.6	95.6	70.1	104.3	72.4	104.0
20-29	27.0	35.9	33.7	44.2	37.4	49.2	37.2	48.0
30-39	62.6	83.8	70.5	94.9	74.6	98.0	79.0	101.8
40-49	207.4	269.9	245.8	315.9	259.5	325.3	248.0	316.5
50-59	370.8	479.5	405.8	537.8	491.8	626.6	553.7	652.7
60-69	329.9	440.5	376.8	511.6	433.6	581.6	467.9	587.7
70+	79.7	144.9	120.1	217.1	171.9	293.3	240.2	298.6
Total	1140.2	1536.7	1318.3	1817.1	1538.8	2078.3	1698.4	2109.2
<b>Female</b>								
0-19	39.4	53.4	44.4	61.9	48.8	68.4	52.8	70.7
20-29	13.4	18.5	19.7	25.2	19.4	26.0	18.0	25.5
30-39	33.2	43.5	37.1	47.9	41.1	52.1	43.9	52.5
40-49	86.1	110.3	94.5	121.7	96.8	122.4	109.7	130.5
50-59	167.5	223.3	188.0	250.8	224.0	287.3	238.0	290.6
60-69	233.2	330.6	253.0	361.3	286.8	392.3	302.6	396.1
70+	171.6	289.4	241.5	402.7	342.7	531.4	441.7	541.6
Total	744.4	1069.0	878.2	1271.4	1059.6	1479.9	1206.5	1507.4
All	1884.6	2605.7	2196.5	3088.5	2598.4	3558.2	2904.9	3616.7

Note. Expressed as million US\$. PWBD = People with Brain Disabilities.

<sup>a</sup>Sum of direct costs, indirect costs.



**Figure 1.** The proportion of economic burden of PWBD by cost items in 2008-2011.

Note. PWBD = People with Brain Disabilities.

**Table 3.** Total Economic Burden of PWBD by Gender and Cost Items in 2008-2011.

Variables	2008		2009		2010		2011	
	Brain-related diseases	All diseases	Brain-related diseases	All diseases	Brain-related diseases	All diseases	Brain-related diseases	All diseases
<b>Male</b>								
Direct medical care <sup>a</sup>	338.7	554.9	440.0	728.1	566.4	889.9	669.4	899.0
Paid by insurer	198.0	315.8	256.7	414.4	322.7	504.9	373.1	504.9
Copayment by patients	41.0	66.9	52.9	85.7	63.6	98.2	75.8	98.2
non-NHIC-covered care costs	23.6	37.7	30.6	49.4	38.5	60.2	44.5	60.2
Assistive devices	76.1	134.5	99.9	178.6	141.7	226.5	176.1	235.6
Direct non-medical care <sup>b</sup>	115.8	203.6	152.6	258.3	195.7	308.0	233.1	320.3
Transportation	4.6	19.0	5.5	22.8	7.8	25.3	8.5	26.3
Nursing costs	111.2	184.6	147.1	235.5	187.9	282.7	224.6	294.0
Indirect <sup>c</sup>	685.6	778.2	725.7	830.7	776.8	880.4	795.9	889.9
Lost productivity	121.6	214.1	153.5	258.5	191.0	294.6	212.4	306.3
Cost of premature death	564.1	564.1	572.2	572.2	585.8	585.8	583.6	583.6
Total cost <sup>d</sup>	1140.2	1536.7	1318.3	1817.1	1538.8	2078.3	1698.4	2109.2
<b>Female</b>								
Direct medical care <sup>a</sup>	308.3	505.6	399.8	649.4	518.2	793.7	614.5	802.1
Paid by insurer	173.7	279.1	226.1	356.3	286.5	434.0	333.1	434.0
Copayment by patients	41.8	66.7	54.0	84.8	65.3	98.0	77.7	98.0
non-NHIC-covered care costs	20.9	33.5	27.1	42.8	34.4	52.2	40.0	52.2
Assistive devices	72.0	126.2	92.6	165.5	132.0	209.5	163.7	217.8
Direct nonmedical care <sup>b</sup>	111.9	187.8	145.1	233.8	185.8	278.6	223.7	289.7
Transportation	3.8	16.0	4.5	19.2	6.3	21.0	6.9	21.8
Nursing costs	108.1	171.8	140.7	214.6	179.5	257.6	216.8	267.9
Indirect <sup>c</sup>	324.2	375.6	333.2	388.2	355.7	407.6	368.3	415.6
Lost productivity	71.0	122.4	87.1	142.1	104.3	156.3	115.2	162.6
Cost of premature death	253.3	253.3	246.1	246.1	251.3	251.3	253.1	253.1
Total cost <sup>d</sup>	744.4	1069.0	874.2	1271.4	1059.6	1479.9	1206.5	1507.4

Note. Expressed as million US\$. PWBD = People with Brain Disabilities; NHIC = National Health Insurance Corporation.

<sup>a</sup>Sum of costs paid by insurer, copayment by patients, noncovered services costs, assistive devices.

<sup>b</sup>Sum of costs of transportation, nursing.

<sup>c</sup>Sum of costs of lost productivity, premature death.

<sup>d</sup>Sum of direct costs, indirect costs.

2011, decreasing by 0.94 to 0.96 times. When wages of the nondisabled were used to calculate the indirect cost, the economic burden was 1.4 to 1.6 times more than the economic burden of brain-related diseases (Table 4).

## Discussion

Our study calculated the economic burden of PWBD in Korea from 2008 to 2011, using nationally representative data for the first time.

The treated prevalence of brain-related diseases and all diseases of PWBD increased during this period. The total cost increased annually by 54% in brain-related diseases and 39% in all diseases of PWBD. The economic burden of all diseases was 1.2 to 1.4 times more than the cost of brain-related diseases, which constituted 4.5% of national health care expenditures and 0.3% of the Korean gross domestic product (GDP).<sup>21,22</sup> The proportion of 0.3% is lower than all

musculoskeletal diseases (0.7% of GDP in 2008), or all cancer (1.75% of GDP in 2005), but is a huge burden in Korea.<sup>9,13</sup>

In this study, we did not compare results from outside the country due to population structure, disease definition, and differences in health care systems. Further research is required to have standardized results for medical resources by type, disease definitions, and status of patients.<sup>23</sup>

According to the NDR, main diseases of brain disorder were composed of stroke, TBI, cerebral palsy, and so on. However, there were studies estimating the cost of stroke, with no studies calculating the economic burden of PWBD, TBI, and cerebral palsy.<sup>8</sup> The cost of stroke in 2010 totaled US\$3.53 billion, which was 1.4 times higher than our result. This difference is attributable to the difference in defining subjects (ie, stroke patients vs. PWBD). To be registered as disabled, it is necessary to experience treatment of more than 6 months after the occurrence of a brain disease such as stroke or trauma. Stroke, however, can require higher initial

**Table 4.** Sensitivity Analysis for Estimating the Economic Burden of PWBD in 2008-2011.

Variables	2008			2009			2010			2011		
	Brain-related diseases	5% <sup>a</sup>	Wages of the nondisabled <sup>b</sup>	Brain-related diseases	5% <sup>a</sup>	Wages of the nondisabled <sup>b</sup>	Brain-related diseases	5% <sup>a</sup>	Wages of the nondisabled <sup>b</sup>	Brain-related diseases	5% <sup>a</sup>	Wages of the nondisabled <sup>b</sup>
Lost productivity	192.52	192.52	360.14	240.63	240.63	414.78	295.27	295.27	512.48	327.56	327.56	578.08
Cost of premature death	817.33	698.24	1816.53	818.27	697.37	1720.58	837.15	713.80	1750.78	836.65	713.05	1735.92
Total cost <sup>c</sup>	1884.58	1765.49	3051.39	2196.46	2075.56	3272.92	2598.44	2475.09	3729.27	2904.90	2781.30	4054.69

Note. Expressed as million US\$. PWBD = People with Brain Disabilities.

<sup>a</sup>Application of 5% discount rate to estimate the indirect costs.

<sup>b</sup>Application of wages of the nondisabled to estimate the indirect costs.

<sup>c</sup>Sum of direct costs, indirect costs.

costs, such as surgery, examinations, and medical treatments. Consequently, the economic burden of PWBD, which did not include initial costs, was lower than the cost of stroke.

The average wages of the disabled should also be considered in calculating indirect costs. According to the 2011 National Survey on PWD, workers with brain disabilities earned US\$1259.42 on average, which is 54.6% of the average wages for all workers (ie, US\$2128.6).<sup>19</sup> People with Brain Disabilities' monthly salary was very low, at US\$1046.6. Thus, the cost of PWBD was estimated to be lower than that of stroke.<sup>2,19</sup>

In addition, the economic burden of all diseases for PWBD was 1.2 to 1.4 times higher than the cost of brain-related diseases for PWBD. This result may be because direct medical costs for geriatric diseases increase due to the increasing of PWBD's prevalence after the age of 65, and rehabilitation treatment costs or management costs of chronic diseases also increased. In the 2014 National Survey on PWD, 88.1% of PWBD had reported chronic diseases for more than 3 months, and the types of diseases were hypertension (66.3%) and diabetes mellitus (29.1%). The proportion of the PWBD who responded that they were treated regularly and consistently was 92.0%. People with Brain Disabilities use medical treatment to prevent secondary diseases, including brain-related diseases.<sup>2</sup> Thus, PWBD must be treated for diverse conditions, such as complications, secondary conditions, and chronic diseases, such as hypertension, diabetes mellitus. Also it is necessary to provide policy of health care offer and cost reduction to secondary diseases of brain disability and be required various health care management policies for improvement of lifestyle.

By gender, disabled men had 1.2 to 1.5 times greater burden than disabled women. This may be due to the prevalence of brain disability. In 2008, the treated prevalence of diseases related to brain disability was 0.3% for men and 0.23% for women, which increased consistently by 0.4% and 0.3% from 2008 to 2011. In case of stroke, which is a major disease in brain disorder, prevalence for male is 2.0%, 0.5% point higher than women's (2011).<sup>24</sup> Also the prevalence of cerebral palsy suggests a similar tendency (male: 3.5 per 1000 persons, female: 2.8 per 1000 persons).<sup>25</sup>

In addition, in the proportion of economic burden of brain disability, there was a difference between men and women. In disabled men, the proportion of indirect costs was 59.1% and was highest in 2008. For disabled women, this proportion was 54.4% and was highest in 2008. The higher rate of indirect cost in the economic burden of disabled men was due to differences in disability employment. According to the 2011 National Survey on PWD, the activity rate of those aged 15 and older was 38.5%.<sup>2</sup> The employment ratio of disabled men compared with the total population was 44.8%, whereas the same ratio for women was 22.7%. The proportion of disabled men was higher than that of disabled women.

The high proportion of direct medical costs in disabled women was because they had a low employment rate and a relatively low average pay. A policy to support employment for women with brain disability who live independently is needed.

By age group, the highest proportion for disabled men was in their 50s, and for disabled women, it was in their 60s and 70s. These results were associated with the characteristics of brain-related diseases. Brain-related diseases were mostly geriatric illnesses such as stroke, Parkinson diseases, and Alzheimer disease, which had a high prevalence in the above 60s age group. In 2014, stroke prevalence for above 50s was 3.6% and showed an increasing tendency by age group, with 1.2% for 50s, 4.6% for 60s, and 7.1% for above 70s.<sup>26</sup> In addition, as the Korea is becoming an aged society, the rate of elderly is increasing. The aging ratio increased 7.8% point from 38.8% in 2011 to 46.6% in 2017, compared with 2011. Health care expenses for PWD above 65 were US\$4.86 billion in 2015, accounting for 52.4% of the total cost of health care. And the health care expense per person for PWD above 65 was US\$473 thousand, 1.5 times higher than the cost per the elderly (2015, US\$1 = 1131.52 won).<sup>17</sup> Thus, health policies for the disabled are necessary to take into account the increasing cost of medical treatment due to the aging of the disabled. Because the increase in health care cost due to the aging of the disabled will be a huge burden on our society.

In our study, it is difficult to compare the result of the economic burden of other countries, because of having different health care systems, demographic structures, medical supplies, health insurance systems. Thus, we need to conduct the cost of illness study using standardized methods according to insurance type, diseases, and medical supplies.

This study had several limitations. First, we defined the patients of brain-related diseases who had a primary diagnoses that was brain-related, excluding secondary diagnoses. We also excluded the pharmaceutical costs incurred by outpatient prescriptions. Thus, it was possible to underestimate direct medical costs, and further study is needed to estimate drug costs for brain-related diseases exactly. Third, we excluded the decline in quality of life due to social and environmental transition, such as psychological pain and anxiety of PWBD and their family after disability registration and intangible costs. Fourth, this study used the rate of non-NHIC-covered care costs of a national rehabilitation hospital in Seoul, which is referred to as N rehabilitation hospital here. However, the rate of non-NHIC-covered care in N rehabilitation hospital was lower than that of other private hospitals. Accordingly, it is possible that we underestimated the economic burden. Finally, we excluded brain and central nervous system cancer (C70-C72) for estimating brain-related diseases. Thus, we possibly underestimated the brain-related diseases cost. However, we calculated the costs 2 ways—brain-related diseases and all diseases (including brain tumor) to address this.



## Conclusions

This study estimated the treated prevalence and economic burden of PWBD for the first time from 2008 to 2011 using nationally representative data.

The economic burden of people with brain disability is substantial, which has been increasing steadily each year. Thus, to reduce the economic burden of people with brain disability, it is necessary to prevent the primary diseases and to have early concentrated treatment and rehabilitation therapy to minimize disability. In addition, health management policy is needed to prevent secondary diseases, which are comorbid with the primary disability.

## Authors' Note

This study was approved by the Institutional Review Board of the Korea National Rehabilitation Center (NRC-2014-04-027). All statistical analyses were conducted using SAS 9.4 (SAS Institute Inc., Cary, NC).

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## ORCID iDs

Hyun-Jin Kim  <https://orcid.org/0000-0002-3844-0090>

Seung Hee Ho  <https://orcid.org/0000-0002-5208-1573>

Sol Lee  <https://orcid.org/0000-0002-5109-6132>

Ju Hee Kim  <https://orcid.org/0000-0002-6222-9201>

Seong Jae Lee  <https://orcid.org/0000-0001-7867-4695>

## Supplementary Material

Supplemental material for this article is available online.

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