

# Analysis of variation in length of stay (LOS) after ischemic and hemorrhagic stroke using the Charlson Comorbidity Index (CCI)

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**Abstract.** [Purpose] The purpose of this study was to understand factors present at baseline that affect outcome and healthcare utilization post-stroke. We investigated the association between the Charlson Comorbidity Index (CCI) score and functional outcome (length of stay) after hemorrhagic and ischemic stroke. [Subjects and Methods] Data from the Korean National Hospital Discharge In-depth Injury Survey for 6 years, from 2005 to 2010, were used. The t-test and analysis of variance were carried out to compare average differences in the length of stay with the general characteristics in accordance with CCI. Multiple regression analysis was carried out using dummy variables to look at factors affecting stroke patients' length of stay. [Results] Independent variables with significant relationships with the log-transformed length of stay included gender, type of insurance, the size of city of residence, the number of beds in the hospital, the location of the medical institution, hospitalization path, receipt of physical therapy, treatment involving brain surgery, death, the type of stroke, and CCI. [Conclusion] The results of the present study suggests that CCI independently influences the length of stay after ischemic and hemorrhagic stroke and that variables with significant relationships with the log-transformed length of stay need to be continuously managed.

**Key words:** Stroke, CCI, Length of stay

*(This article was submitted Sep. 2, 2014, and was accepted Oct. 24, 2014)*

## INTRODUCTION

Stroke takes a heavy toll on affected individuals and their families. Survivors are often chronically impaired in their movements and are left with long-term disabilities<sup>1)</sup>. Understanding factors present at baseline that affect outcome and healthcare utilization post-stroke is important. The most useful tool for the indirect evaluation of the functional outcome of and service quality variation for stroke is the average length of stay<sup>2)</sup>. Some of the main variables that can predict the average length of stay are stroke severity, age, comorbidity, education, and depression<sup>3)</sup>. Medical comorbidities are common in patients with spontaneous intracerebral hemorrhage and ischemic stroke<sup>4, 5)</sup>. A comorbidity is defined as a clinical condition that exists at the time of the onset of the event which is likely to influence the outcome under study<sup>6)</sup>. The Charlson Comorbidity Index (CCI) accounts for multiple comorbidities by creating a sum score, weighted according to the presence of various conditions, and is commonly used in outcome and mortality studies. Although it

may seem intuitive that comorbid conditions would influence outcome and mortality after stroke, few studies have, in fact, evaluated the independent impact of such comorbidities<sup>7, 8)</sup>. Thus, this study was carried out to investigate the association between CCI score and functional outcome (length of stay) after hemorrhagic and ischemic stroke.

## SUBJECTS AND METHODS

Data from the Korean National Hospital Discharge In-depth Injury Survey for 6 years, from 2005 to 2010, were used. The Korean National Hospital Discharge In-depth Injury Survey was initiated in 2004 by the Korean Centers for Disease Control based on the U.S. National Hospital Discharge Survey methodology. Data from ~170 general hospitals with 100 or more beds were surveyed, based on discharge summary data from discharged patients' medical records. Survey items included information on medical institutions, patient admissions, diseases, and treatments, demographic and geographic information.

Stroke patient cases were defined as the 21,494 cases with principal diagnosis codes I60, I61, I62, and I63, according to the International Classification of Disease, and they were analyzed after dividing the cases into hemorrhagic (I60, I61, and I62) and ischemic (I63) stroke cases.

The length of stay, a dependent variable, was calculated using the dates of hospitalization and discharge recorded in the Korean National Hospital Discharge In-depth Injury

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**Table 1.** Distribution of comorbidity in stroke patients (unit: n, %)

Condition	CCI weight	Hemorrhagic (160-162) (n=6,925)		Ischemic (163) (n=14,569)	
		Yes	No	Yes	No
Myocardial infarction	1	30 (0.4)	6,895 (99.6)	102 (0.7)	14,467 (99.3)
Congestive heart failure	1	83 (1.2)	6,842 (98.8)	510 (3.5)	14,059 (96.5)
Peripheral vascular disease	1	44 (0.6)	6,881 (99.4)	144 (1.0)	14,425 (99.0)
Cerebrovascular disease	1	2,166 (31.3)	4,759 (68.7)	2,089 (14.3)	12,480 (85.7)
Dementia	1	84 (1.2)	6,841 (98.8)	333 (2.3)	14,236 (97.7)
Chronic pulmonary disease	1	60 (0.9)	6,865 (99.1)	240 (1.6)	14,329 (98.4)
Connective tissue disease	1	13 (0.2)	6,912 (99.8)	37 (0.3)	14,532 (99.7)
Ulcer	1	76 (1.1)	6,849 (98.9)	199 (1.4)	14,370 (98.6)
Mild liver disease	1	186 (2.7)	6,739 (97.3)	262 (1.8)	14,307 (98.2)
Diabetes	1	700 (10.1)	6,225 (89.9)	3,530 (24.2)	11,039 (75.8)
Diabetes with end-organ damage	2	63 (0.9)	6,862 (99.1)	391 (2.7)	14,178 (97.3)
Hemiplegia	2	632 (9.1)	6,293 (90.9)	1,192 (8.2)	13,377 (91.8)
Moderate or severe renal disease	2	97 (1.4)	6,828 (98.6)	215 (1.5)	14,354 (98.5)
Leukemia, lymphoma, any tumor	2	93 (1.3)	6,832 (98.7)	250 (1.7)	14,319 (98.3)
Moderate or severe liver disease	3	15 (0.2)	6,910 (99.8)	13 (0.1)	14,556 (99.9)
Metastatic solid tumor	6	18 (0.3)	6,907 (99.7)	59 (0.4)	14,510 (99.6)
Acquired immune deficiency syndrome	6	0 (0.0)	6,925 (100.0)	1 (0.0)	14,568 (100.0)

CCI: Charlson Comorbidity Index

Survey. Independent variables included demographic characteristics, characteristics of medical institutions, medical service utilization characteristics, and CCI. Medical service utilization characteristics included admission route, physical therapy, brain surgery, and CCI, and they were used to reflect the severity of disease.

Evaluation and comparison of medical effects and medical care outcomes should adjust patients' comorbidity risks systematically together with the severity of the main diagnosis for qualitative differences in medical care and proper outcome evaluation. Thus, comorbidity risk adjustment is critical.

CCI is the most widely used comorbidity adjustment method. A weight, from one to six points, is provided for 19 diseases, and the sum of the weights is adjusted. Generally, the method provides evaluations by categorizing the score into zero, one, two, and  $\geq 3$ .

For statistical analyses, the SAS software (ver. 9.2) was used. Frequency analysis was conducted to examine comorbidity distribution in the subjects, and the t-test and analysis of variance (ANOVA) were carried out to compare average differences in the lengths of stay by general characteristics, in accordance with CCI. Multiple regression analysis was carried out using dummy variables to assess factors affecting stroke patients' length of stay. To examine the effects of CCI in more detail, Model 1, including variables of general characteristic factors only, and Model 2, including CCI and general characteristic factors, were developed. A multiple regression analysis using dummy variables was carried out to examine factors affecting stroke patients' length of stay. Equal variance and the normality of the length of stay, the dependent variable, were reviewed and found to be non-normally distributed. Thus, the lengths of stay were log-transformed before being used in the analysis.

## RESULTS

The distribution of each comorbidity in 6,925 hemorrhagic stroke patients and 14,569 ischemic stroke patients was investigated. According to the analysis of hemorrhagic stroke patients, cerebrovascular disease accounted for the largest proportion among the comorbidities, followed by diabetes with no complications at 10.1% and hemiplegia at 9.1%. In ischemic stroke patients, diabetes with no complications comprised 24.2% of comorbidities, followed by cerebrovascular disease at 14.3% and hemiplegia at 8.2% (Table 1).

To examine differences in the lengths of stay by general characteristics according to hemorrhagic stroke patients' CCI, the t-test and ANOVA were performed. The length of stay of those aged between 50 and 64 years among hemorrhagic stroke patients was longest, and the type of insurance with the longest length of stay was 'other' insurance, followed by Medicaid and national health insurance. Regarding the number of beds, the length of stay was longest when the hospital had 300–499 beds. When physical therapy was conducted, brain surgery was performed, or when patients died, the lengths of stay were longer. The lengths of stay were statistically significantly different according to hemorrhagic stroke patients' age, type of insurance, number of hospital beds, physical therapy, brain surgery, and death (Table 2).

To examine differences in ischemic stroke patients' lengths of stay by general characteristics according to CCI, the t-test and ANOVA were carried out. The type of insurance with the longest length of stay among ischemic stroke patients was 'other' insurance, followed by Medicaid and national health insurance. The lengths of stay were longest when the patients lived in a large city and when they were admitted to a hospital with 300–499 beds. The lengths of

**Table 2.** Differences in the lengths of stay by general characteristics according to hemorrhagic stroke patients' CCI

Variables		CCI=0 Mean±SD	CCI=1 Mean±SD	CCI=2 Mean±SD	CCI≥3 Mean±SD	Total Mean±SD
Gender	Male	24.4±39.7	28.4±47.8	46.3±73.6	65.3±81.9	32.3±54.1
	Female	25.3±64.3	30.8±52.9	47.9±78.5	54.8±58.7	32.4±64.0
Age	<50	23.6±41.3	27.9±41.5**	51.2±65.2	74.4±76.2*	32.0±50.7**
	50–64	27.2±59.3	36.6±72.4	44.9±62.2	56.7±72.7	35.2±65.4
	65–74	24.5±53.7	26.9±30.3	49.6±91.8	61.4±78.4	32.4±59.6
	≥75	23.0±59.1	23.5±31.0	41.6±92.0	45.0±48.7	27.0±58.1
Insurance type	Health insurance	22.6±47.2**	26.6±38.0**	42.8±64.9**	54.6±66.6**	29.1±50.9**
	Medicaid	37.5±71.0	50.0±101.0	58.4±77.9	87.8±77.6	50.0±84.2
	Others	61.8±124.6	50.8±67.7	109.4±183.6	115.6±128.7	74.9±132.9
Residence urban size	Metropolitan	24.7±44.2	31.3±58.3	46.7±68.1	56.4±74.3	32.4±56.1
	Urban	25.1±56.3	30.4±48.1	51.9±92.6	62.4±66.2	33.4±62.5
	Rural	24.5±66.6	23.3±28.8	35.4±39.3	64.8±82.2	29.0±58.4
Bed size	100–299	31.1±63.1**	29.4±51.6	52.4±80.3*	59.9±68.8	34.8±63.8**
	300–499	35.3±85.1	32.7±48.0	61.3±111.0	75.3±92.1	42.6±83.7
	500–999	22.8±46.8	30.5±53.9	44.7±70.1	60.2±69.6	31.5±56.2
	≥1,000	17.9±23.4	23.4±32.9	37.6±44.3	47.4±59.0	24.5±34.9
Hospital location	Seoul	23.5±49.0	32.3±71.5	46.0±74.8	65.4±72.1*	33.4±63.1
	Metropolitan	24.0±35.0	30.7±48.3	42.1±52.6	47.4±67.8	30.1±45.3
	Gyeonggi	23.9±47.8	26.7±32.9	50.5±90.0	60.3±53.9	31.7±54.5
	Others	27.6±74.3	28.1±41.1	52.6±92.0	67.9±83.7	34.6±72.3
Admission route	Emergency	25.2±52.3	29.88±49.67	47.35±71.49	60.85±69.89	32.84±57.66
	Ambulatory	23.1±58.5	28.34±56.11	45.67±101.05	56.70±82.61	29.60±67.36
Physical therapy	No	22.5±47.2**	26.9±47.0**	42.8±78.4**	55.8±72.1**	28.8±55.2**
	Yes	53.0±98.1	60.8±73.5	65.7±62.4	76.8±68.5	62.0±80.9
Brain surgery	No	22.7±53.4**	25.2±47.6**	37.4±66.0**	47.6±73.4**	27.0±56.0**
	Yes	29.8±53.5	37.5±54.4	62.0±87.4	74.9±67.2	42.5±64.0
Death	No	25.9±48.5*	32.8±47.2**	52.5±72.4**	66.4±73.2**	34.7±56.0**
	Yes	17.1±82.2	17.1±60.4	21.8±87.5	28.9±54.3	19.0±73.7
Total		24.8±53.5	29.7±50.5	47.1±76.1	60.3±71.8	32.3±59.3

\*p&lt;0.05, \*\*p&lt;0.01

stay according to admission route were longer when patients were admitted from an emergency room. The lengths of stay were also longer when patients received physical therapy or brain surgery. The lengths of stay according to ischemic stroke patients' type of insurance, size of the city where they resided, the number of beds at the hospital, and receipt of physical therapy and brain surgery were statistically significantly different (Table 3).

## DISCUSSION

To examine factors affecting stroke patients' lengths of stay, a multiple regression analysis using dummy variables was conducted. For Model 1, which included general characteristics variables only, significance was accepted for p values < 0.001, a much lower level than a significance level of 0.05; thus, Model 1 was a significant regression model. Its explanatory power was 17.3%. Independent variables with significant relationships with the log-transformed lengths of stay in Model 1 included the type of insurance, the size of city in which patients resided, the number of beds at the

hospital, the location of the medical institution, admission route, receipt of physical therapy, brain surgery, death, and the type of stroke.

For Model 2, which included patients' general characteristics and CCI variables, significance was accepted for p values < 0.001, a much lower level than a significance level of 0.05; thus, this was also a significant regression model. The explanatory power of the model was 21.4%, higher than that of Model 1. Independent variables with significant relationships with the log-transformed lengths of stay in Model 2 included gender, the type of insurance, the size of city in which the patients resided, the number of beds at the hospital, the location of the medical institution, admission route, receipt of physical therapy, brain surgery, death, the type of stroke, and CCI. The length of stay was longer for females than males. The length of stay according to type of insurance was longest with 'other' insurance, followed by Medicaid and national health insurance. The length of stay was longest for those residing in large cities, when the number of beds in the hospital was 300–499, and when the medical institution was located in a metropolitan city. The lengths of stay

**Table 3.** Differences in the lengths of stay by general characteristics according to ischemic stroke patients' CCI

Variables		CCI=0 Mean±SD	CCI=1 Mean±SD	CCI=2 Mean±SD	CCI≥3 Mean±SD	Total Mean±SD
Gender	Male	13.4±22.9	15.7±24.3	24.09±40.43	31.08±46.36	17.07±29.46
	Female	14.3±23.6	16.8±27.7	24.12±36.26	32.53±38.81	17.57±28.39
Age	<50	12.7±25.4*	14.6±20.4	26.7±44.8	34.1±42.6	16.2±29.4
	50–64	13.9±27.0	16.2±27.6	23.6±30.7	34.5±56.7	17.5±31.8
	65–74	13.1±17.5	16.0±28.3	23.3±36.1	31.2±38.1	17.0±26.8
	≥75	15.0±24.3	17.1±21.7	24.8±46.3	28.6±34.1	17.9±28.6
Insurance type	Health insurance	13.0±21.0**	15.3±22.2**	22.8±32.9**	30.7±43.4**	16.3±26.2**
	Medicaid	19.8±28.7	23.4±44.5	33.3±67.8	34.4±33.7	23.9±41.3
	Others	25.1±78.9	25.6±43.2	31.3±32.3	135.2±124.0	31.6±71.2
Residence urban size	Metropolitan	14.5±26.3	16.5±25.0	24.4±39.1	30.7±41.5	18.1±30.4*
	Urban	13.7±22.9	16.0±24.1	23.4±31.2	33.6±49.8	17.0±27.8
	Rural	12.8±16.6	16.1±32.0	25.2±51.9	29.0±27.1	16.2±28.6
Bed size	100–299	17.8±32.5**	20.1±28.3**	33.9±67.4**	35.5±52.5	20.8±38.0**
	300–499	17.4±28.2	23.4±44.3	21.7±25.2	38.3±71.2	21.4±38.6
	500–999	11.9±17.5	14.2±20.5	22.2±29.5	30.1±37.6	15.6±23.4
	≥1,000	10.8±14.0	13.1±17.3	23.3±37.3	29.5±25.6	15.3±22.1
Hospital location	Seoul	12.3±22.2*	16.1±23.2	23.0±31.5	34.0±43.7*	17.5±28.2
	Metropolitan	15.0±24.8	15.8±23.8	24.1±47.1	26.0±32.6	17.3±29.5
	Gyeonggi	13.0±25.6	15.7±24.9	22.7±33.3	34.0±37.4	16.6±28.2
	Others	14.0±21.3	17.1±30.4	25.9±36.1	33.6±55.1	17.4±29.5
Admission route	Emergency	13.8±21.3	16.5±27.0	25.1±42.2	32.0±45.1	17.7±29.6*
	Ambulatory	13.8±27.1	15.6±22.8	21.4±26.6	30.7±38.3	16.4±27.3
Physical therapy	No	12.6±20.8**	14.9±24.9**	20.7±30.7**	29.2±44.2**	15.4±26.0**
	Yes	26.0±37.7	28.1±31.4	40.1±61.5	39.2±40.7	31.5±42.9
Brain surgery	No	13.6±22.5**	15.7±24.1**	23.6±38.2**	29.9±40.3**	16.8±27.7**
	Yes	40.7±61.4	66.1±83.6	65.5±49.1	91.4±90.1	61.4±74.6
Death	No	13.6±21.7	16.1±24.9	24.5±39.2	31.6±42.2	17.2±28.0
	Yes	19.6±49.8	20.0±44.3	16.6±26.1	33.2±64.6	20.7±47.4
Total		13.8±23.2	16.2±25.9	24.1±38.7	31.7±43.5	17.3±29.0

\*p&lt;0.05, \*\*p&lt;0.01

were longer when patients were admitted to a hospital from an emergency room than hospitalization through outpatient care. The length of stay was longer when patients received physical therapy or brain surgery, when the patient died, and when the stroke type was hemorrhagic, rather than ischemic. The higher the CCI was, the longer the length of stay was.

Comorbidities can compromise recovery from a stroke. Knowledge of variables, including CCI, that affect functional outcome after intracerebral hemorrhage and ischemic stroke assist the targeting of programs that can help reduce risk factors and distribute resources for stroke management<sup>9)</sup>.

Although using the CCI may be questionable because it was developed to predict mortality and morbidity, high comorbidity, as measured by the CCI, has also been associated with poorer outcomes after acute stroke<sup>7, 10)</sup>. In this study, the CCI score was independently associated with the lengths of stay after hemorrhagic and ischemic stroke. The mean length of stay for stroke patients using medical facilities was 5.3 days in the United States, 7 days in Canada, and 12.7 days in France<sup>11–13)</sup>. However, the average length of stay in Korea is longer than in these other countries. This indicates

that our country does not effectively manage the length of stay of stroke patients in medical institutions. Reduction of the length of stay is being encouraged at acute hospitals, so physical therapists must provide patients with rehabilitation programs that achieve the desired functional outcome<sup>14, 15)</sup>.

Thus, to develop national standard clinical guidelines and medical care for stroke patients, variables with significant relationships with the lengths of stay, including physical therapy, need to be continuously managed.

#### ACKNOWLEDGEMENT

This research was supported by a Youngsan University Research Grants in 2014.

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