Trends in Mortality from Hemorrhagic Stroke in Korea from 2012 to 2020

Kwang-Chun Cho, MD, PhD[1,2], Hasung Kim, MPH[3], Sang Hyun Suh, MD, PhD[4]

[1]Department of Neurosurgery, Yongin Severance Hospital, Yonsei University College of Medicine, Yongin, Korea
[2]Department of Neurosurgery, International St. Mary's Hospital, Catholic Kwandong University College of Medicine, Incheon, Korea
[3]Data Science Team, Hanmi Pharm. Co., Ltd., Seoul, Korea
[4]Department of Radiology, Gangnam Severance Hospital, Yonsei University College of Medicine, Seoul, Korea

Purpose: To analyze trends in mortality rates from hemorrhagic stroke (HS) according to HS subtypes, using nationwide data from January 2012 to December 2020.

Materials and Methods: We used data from the National Health Claims Database provided by the National Health Insurance Service for 2012–2020 using the International Classification of Disease. The age-adjusted mortality rates of HS, which included subarachnoid hemorrhage (SAH) and intracerebral hemorrhage (ICH), were calculated, and additional analyses were conducted according to age and sex.

Results: The age-adjusted mortality rates for HS, SAH, and ICH decreased substantially in both sexes between 2012 and 2020. During the study period, mortality rates for HS decreased from 8.87 deaths per 100,000 inhabitants to 6.27 deaths per 100,000 inhabitants. Regarding SAH, mortality rates decreased from 3.72 deaths per 100,000 inhabitants to 2.57 deaths per 100,000 inhabitants. Concerning ICH, mortality rates decreased from 6.91 deaths per 100,000 inhabitants to 4.75 deaths per 100,000 inhabitants. The average annual percentage change for HS, SAH, and ICH was −0.04, −0.04, and −0.05, respectively. Mortality rates from HS, SAH, and ICH in both sexes decreased from 2012 to 2020 in all age groups.

Conclusion: In Korea, the age-adjusted mortality rate of HS, SAH, and ICH demonstrated a declining trend in both sexes and across all age groups. These results may aid in the design and improvement of preventive strategies.

Key Words: Hemorrhagic stroke; Mortality rate; Trends; Korea

INTRODUCTION

Stroke is the second most common cause of death worldwide after coronary heart disease.[1] In Korea, stroke accounts for a large proportion of the disease population, ranking fourth in mortality. Fortunately, a decline in stroke mortality over the last few decades has been observed in many countries.[2-5] A similar trend is emerging in Korea, which might be due to improvements in the management of stroke and effective control of risk factors.

Among stroke subtypes, the incidence of hemorrhagic stroke (HS) is decreasing annually, but the mortality rate is considered higher than that of ischemic stroke. However, because most studies have been focused on ischemic stroke, or in-

vestigated a HS only as a subtype of stroke, intensive studies on HS have been relatively insufficient. Understanding recent trends in stroke mortality is fundamental for controlling and treating stroke. While the mortality trend of stroke has been reported in several Korean studies, recent mortality rates have not yet been investigated.[6]

Therefore, the present study evaluated the mortality trends of HS in Korea from 2012 to 2020.

MATERIALS AND METHODS

Subjects

The National Health Insurance Service (NHIS) in Korea is a nationwide universal insurance system responsible for the nation's healthcare and medical expenses. Therefore, this database contains the hospital records of 97% of the Korean population. Furthermore, the NHIS operates a severe disease registration system that supports medical expenses for patients, and strict diagnostic criteria must be met for registration. Accordingly, the NHIS database, which covers a single-ethnicity population of 50 million people, is expected to include information from all stroke patients and is optimal for epidemiological studies on HS. Therefore, we analyzed the incidence and treatment trends of HS according to subtype using the NHIS data from January 2012 to December 2020.

This study was based on data collected from the Korean NHIS and Statistics Data in Korea. Causes of death were coded according to the International Classification of Disease,

10th revision (ICD-10). HS was coded as I60, I61, or I62. Subarachnoid hemorrhage (SAH) was coded as I60 and intracerebral hemorrhage (ICH) as I61 or I62.

Statistical Analysis

Age-adjusted mortality rates for each 10-year age group were calculated for HS using the NHIS data from 2012 to 2020 and Statistics Data in Korea. Mortality data were obtained from the NHIS data and population data were obtained from the resident registration population reported by Statistics Korea. The mid-year population on July 1 of the respective year was used when computing the data. In addition, the age-adjusted mortality rates per 100,000 population during the 2012–2020 period and the corresponding confidence intervals were calculated using the direct method according to the Korean standard population.

The results were stratified and analyzed according to sex, age, and subtype of HS group (SAH and ICH). In addition, we used a joinpoint regression model (joined linear segments from Poisson regression models) analysis to determine the points where the linear slope of the stroke mortality trend changed significantly over the analysis period. It was assumed that the age-adjusted mortality rates followed a Poisson distribution. Furthermore, a statistically significant change was set at $P<0.05$. We determined the average annual percentage change (AAPC) for the 2012–2020 period.

Statistical analyses were performed utilizing SAS version 9.4. software (SAS Institute, Inc., Cary, NC, USA).
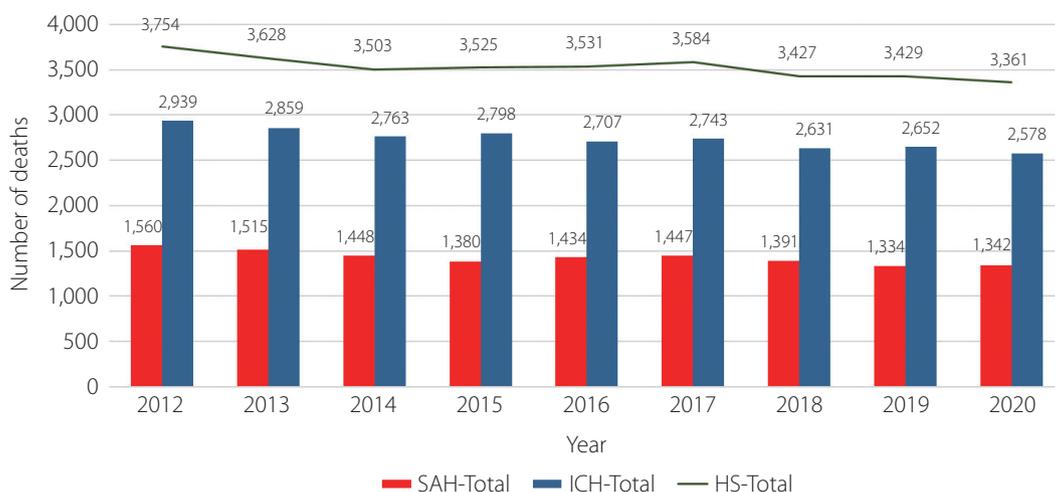

Fig. 1. Annual deaths from hemorrhagic stroke (HS) in Korea between 2012 and 2020. SAH, subarachnoid hemorrhage; ICH, intracerebral hemorrhage.
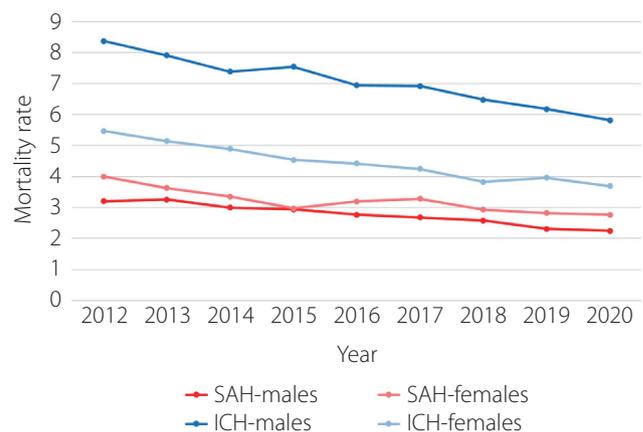
Table 1. Age-adjusted mortality rates by subtypes of hemorrhagic stroke and sex from 2012 to 2020 in Korea

| Type | Sex | Mortality rate | | AAPC (2012–2020) | 95% CI | |
		2012	2020		Lower	Upper
HS	Total	8.87	6.27	−0.04	−0.58	0.50
	Male	9.97	7.08	−0.04	−0.64	0.55
	Female	7.68	5.41	−0.04	−0.53	0.44
SAH	Total	3.72	2.57	−0.05	−0.30	0.20
	Male	3.20	2.25	−0.04	−0.28	0.19
	Female	4.00	2.77	−0.05	−0.31	0.22
ICH	Total	6.91	4.75	−0.05	−0.51	0.42
	Male	8.37	5.82	−0.05	−0.59	0.49
	Female	5.47	3.69	−0.05	−0.45	0.35

AAPC, average annual percentage change; CI, confidence interval; HS, hemorrhagic stroke; SAH, subarachnoid hemorrhage; ICH, intracerebral hemorrhage.
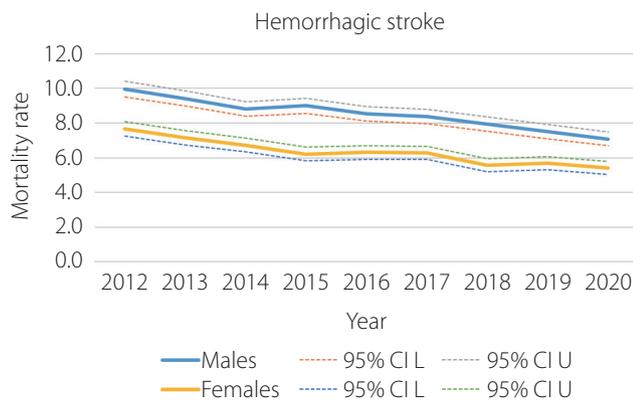
Fig. 2. Age-adjusted mortality rates from hemorrhagic stroke for all age groups by sex. CI, confidence interval; L, lower limit; U, upper limit.

Fig. 3. Age-adjusted mortality rates from subarachnoid hemorrhage (SAH) and intracerebral hemorrhage (ICH) for all age groups by sex.

RESULTS

Demographic information for patients with HS is presented in Fig. 1 (Supplementary Table 1). The age-adjusted mortality rates for HS decreased substantially in both sexes from 2012 to 2020. The mortality rates for SAH and ICH in both sexes also decreased during this period (Table 1). Fig. 2 (Supplementary Table 2) shows the trends in age-adjusted mortality rates due to HS according to sex. This trend in mortality rate was also observed for the HS subtypes (SAH and ICH) (Fig. 3, Supplementary Table 3).

During the study period, mortality rates for HS decreased from 8.87 deaths per 100,000 inhabitants to 6.27 deaths per 100,000 inhabitants; the AAPC was −0.04 (−0.58 to 0.50). Regarding SAH, mortality rates decreased from 3.72 deaths per 100,000 inhabitants to 2.57 deaths per 100,000 inhabitants; the AAPC was −0.05 (−0.30 to 0.2). Concerning ICH, mortality rates decreased from 6.91 deaths per 100,000 inhabitants to 4.75 deaths per 100,000 inhabitants; the AAPC was −0.05 (−0.51 to 0.42).

Additionally, for both sexes, all age groups experienced a decline in mortality due to HS, SAH, and ICH between 2012 and 2020 (Table 2).

During the study period, in both HS and SAH, males aged 18–49 and 50–69 years showed a more prominent trend in mortality than females. However, the mortality rates were higher for females aged 70 years and older than for males in the same group throughout the study period. In contrast, in ICH, the age-adjusted mortality rate of males at all ages was higher than that of females.

Table 2. Age-adjusted mortality rates from HS, SAH, and ICH, by sex and age group from 2012 to 2020 in Korea

Type	Sex	Age (y)	Mortality rate		AAPC (2012–2020)	95% CI	
			2012	2020		Lower	Upper
HS	Male	18–49	2.73	1.81	−0.05	−0.28	0.18
		50–69	3.98	2.98	−0.04	−0.33	0.26
		70 and older	3.25	2.29	−0.04	−0.24	0.15
	Female	18–49	1.58	1.04	−0.05	−0.35	0.25
		50–69	2.46	1.91	−0.03	−0.19	0.12
		70 and older	3.63	2.46	−0.05	−0.15	0.05
SAH	Male	18–49	1.22	0.73	−0.06	−0.17	0.04
		50–69	1.28	1.08	−0.02	−0.11	0.07
		70 and older	0.69	0.44	−0.06	−0.11	0.00
	Female	18–49	0.89	0.60	−0.05	−0.13	0.03
		50–69	1.48	1.13	−0.03	−0.13	0.06
		70 and older	1.63	1.04	−0.06	−0.17	0.05
ICH	Male	18–49	2.02	1.33	−0.05	−0.23	0.12
		50–69	3.35	2.41	−0.04	−0.25	0.17
		70 and older	3.30	2.08	−0.05	−0.22	0.13
	Female	18–49	1.00	0.65	−0.05	−0.15	0.04
		50–69	1.61	1.16	−0.04	−0.17	0.09
		70 and older	2.87	1.89	−0.05	−0.25	0.15

HS, hemorrhagic stroke; SAH, subarachnoid hemorrhage; ICH, intracerebral hemorrhage; AAPC, average annual percentage change; CI, confidence interval.

Among males, the age-adjusted mortality rate in the 50–69 years age group was the highest for HS, SAH, and ICH. The AAPC also showed the least negative change in that age group, which means that the decrease in mortality rates was the lowest. Among females, the mortality rates in patients aged 70 years and older were the highest for HS, SAH, and ICH.

DISCUSSION

The results for HS mortality in Korea showed an overall decline from 2012 to 2020. The decline in the mortality rate due to stroke may be due to a decline in smoking and blood pressure, together with an increase in the use of antihypertensive treatment.[7,8] Accordingly, this may be because acute stroke events have become less severe, and the mortality rate of stroke patients is decreasing.[6]

A declining trend in mortality rate was observed for SAH and ICH. With regard to SAH, the mortality rate decreased over 9 years. According to a previous study, the incidence

of unruptured intracranial aneurysms (UIAs) in Korea has steadily increased, and the incidence of SAH has gradually decreased.[9,10] As UIAs are treated before SAH, this tendency could reduce the incidence and mortality of SAH. In a previous study, a crude incidence of SAH in 2008 and 2016 was 16.8 per 100,000 person-years and 15.5 per 100,000 person-years, respectively.[10] Therefore, it is possible that these findings could be due to an increase in the treatment of UIAs and the management of hypertension through health screening.[10,11] In cases of ICH, the mortality rate also decreased. However, it still showed a higher mortality rate than SAH, with respect to age and sex, as shown in previous studies.[12-14]

Males had a higher mortality rate of HS and ICH than females, while females had a higher mortality rate of SAH than males. This trend is similar to that observed in other countries, such as in Austria and Brazil.[15,16] Some studies have attributed these differences to hormone-dependent mechanisms, genetic dissimilarities, and differences in accessibility and quality of healthcare.[17]

The mortality rate in the 50–69 age group was the highest

among males. In contrast, females older than 70 years had the highest mortality rate. The increase in stroke mortality among females of advanced age could be a consequence of their postmenopausal status.[17,18]

There are slight differences in HS mortality by age and sex, but it shows an overall decline. This is not unique to Korea and is due to global medical development and an increase in medical care.[8,18] Therefore, it seems that efforts should be made to reduce comorbidities such as hypertension, diabetes mellitus, smoking, and alcohol drinking.

This study is not without limitations. Although this study was based on statistics from the NHIS, caution should be exercised due to limitations in official health statistics and surveillance mortality systems. The validity of the cause of death could be discussed because Statistics Korea published statistics on the cause of death, mainly based on death certificates. In addition, in cases where HS was diagnosed and the patient died, it might not be determined that the cause of death was HS. Some authors investigated whether there are still a significant number of deaths recorded without underlying causes in the Death Statistics. In 2012, 9.4% of deaths were classified as unknown.[6] In these cases, there was a possibility of underestimation or overestimation of the mortality. We used age, sex, and subtype as parameters commonly used in studies on epidemiology. In this study, regional analysis was not presented, since it was judged that there were not many differences in regional data in Korea.

CONCLUSION

This analysis is not conclusive and further epidemiological studies based on populations are necessary to identify risk factors and explain potential preventive strategies. We need to monitor the trends in mortality from HS. However, our results may aid in designing and improving preventive strategies.

SUPPLEMENTARY MATERIALS

Supplementary materials related to this article can be found online at https://doi.org/10.5469/neuroint.2022.00220.

Conflicts of Interest

SHS has been the next Editor-in-chief of the *Neurointervention* since 2022. No potential conflict of interest relevant to this article was reported.

Author Contributions

Concept and design: KCC and SHS. Data collection: HSK. Writing the article: KCC. Final approval of the article: SHS. Overall responsibility: KCC.

ORCID

Kwang-Chun Cho: http://orcid.org/0000-0002-0261-9283
Hasung Kim: http://orcid.org/0000-0002-2519-6244
Sang Hyun Suh: http://orcid.org/0000-0002-7098-4901

REFERENCES

1. Deaton C, Froelicher ES, Wu LH, Ho C, Shishani K, Jaarsma T. The global burden of cardiovascular disease. *Eur J Cardiovasc Nurs* 2011;10 Suppl 2:S5-S13

2. Feigin VL, Lawes CM, Bennett DA, Anderson CS. Stroke epidemiology: a review of population-based studies of incidence, prevalence, and case-fatality in the late 20th century. *Lancet Neurol* 2003;2:43-53

3. Sarti C, Rastenyte D, Cepaitis Z, Tuomilehto J. International trends in mortality from stroke, 1968 to 1994. *Stroke* 2000;31:1588-1601

4. Kunst AE, Amiri M, Janssen F. The decline in stroke mortality: exploration of future trends in 7 Western European countries. *Stroke* 2011;42:2126-2130

5. Pham TM, Fujino Y, Kubo T, Murata A, Le DC, Ozasa K, et al. Premature mortality due to stroke and trend in stroke mortality in Japan (1980-2005). *Eur J Public Health* 2011;21:609-612

6. Lee SW, Kim HC, Lee HS, Suh I. Thirty-year trends in mortality from cerebrovascular diseases in Korea. *Korean Circ J* 2016;46:507-514

7. Harmsen P, Tsipogianni A, Wilhelmsen L. Stroke incidence rates were unchanged, while fatality rates declined, during 1971-

1987 in Göteborg, Sweden. *Stroke* 1992;23:1410-1415

8. Hong KS, Bang OY, Kang DW, Yu KH, Bae HJ, Lee JS, et al. Stroke statistics in Korea: part I. Epidemiology and risk factors: a report from the Korean Stroke Society and Clinical Research Center For Stroke. *J Stroke* 2013;15:2-20

9. Lee EJ, Lee HJ, Hyun MK, Choi JE, Kim JH, Lee NR, et al. Rupture rate for patients with untreated unruptured intracranial aneurysms in South Korea during 2006-2009. *J Neurosurg* 2012;117:53-59

10. Lee SU, Kim T, Kwon OK, Bang JS, Ban SP, Byoun HS, et al. Trends in the incidence and treatment of cerebrovascular diseases in Korea: part II. Cerebral infarction, cerebral arterial stenosis, and Moyamoya disease. *J Korean Neurosurg Soc* 2020;63:69-79

11. Lee JH, Yang DH, Park HS, Cho Y, Jun JE, Park WH, et al.; HYpertension-Diabetes Daegu Initiative Study Investigators. Incidence of hypertension in Korea: 5-year follow-up study. *J Korean Med Sci* 2011;26:1286-1292

12. Avezum Á, Costa-Filho FF, Pieri A, Martins SO, Marin-Neto JA. Stroke in Latin America: burden of disease and opportunities for prevention. *Glob Heart* 2015;10:323-331

13. Cruz C, Campuzano-Rincón JC, Calleja-Castillo JM, Hernández-Álvarez A, Parra MD, Moreno-Macias H, et al. Temporal trends in mortality from ischemic and hemorrhagic stroke in Mexico, 1980-2012. *J Stroke Cerebrovasc Dis* 2017;26:725-732

14. Sarti C, Stegmayr B, Tolonen H, Mähönen M, Tuomilehto J, Asplund K; WHO MONICA Project. Are changes in mortality from stroke caused by changes in stroke event rates or case fatality? Results from the WHO MONICA project. *Stroke* 2003;34:1833-1840

15. Bajaj A, Schernhammer ES, Haidinger G, Waldhör T. Trends in mortality from stroke in Austria, 1980-2008. *Wien Klin Wochenschr* 2010;122:346-353

16. Lotufo PA, Goulart AC, Fernandes TG, Benseñor IM. A reappraisal of stroke mortality trends in Brazil (1979-2009). *Int J Stroke* 2013;8:155-163

17. Haast RA, Gustafson DR, Kiliaan AJ. Sex differences in stroke. *J Cereb Blood Flow Metab* 2012;32:2100-2107

18. Reeves MJ, Bushnell CD, Howard G, Gargano JW, Duncan PW, Lynch G, et al. Sex differences in stroke: epidemiology, clinical presentation, medical care, and outcomes. *Lancet Neurol* 2008;7:915-926