J Korean Med Sci. 2026 Apr 13;41(14):e113
https://doi.org/10.3346/jkms.2026.41.e113
eISSN 1598-6357·pISSN 1011-8934

JKMS

Original Article

Public Health & Preventive Medicine

Check for updates

# Trends in Acute Care and Rehabilitation for First-Ever Stroke Patients: A 12-Year Perspective, the KOSCO Study

**Dae Hyun Kim**,[1] **Min Kyun Sohn**,[2] **Jongmin Lee**,[3] **Deog Young Kim**,[4] **Yong-Il Shin**,[5] **Gyung-Jae Oh**,[6] **Yang-Soo Lee**,[7] **Min Cheol Joo**,[8] **So Young Lee**,[9] **Min-Keun Song**,[10] **Junhee Han**,[11] **Jeonghoon Ahn**,[12] **Ho Seok Lee**,[1*] **Yun-Hee Kim**,[13] **and Won Hyuk Chang**[1,14]

[1]Department of Physical and Rehabilitation Medicine, Center for Prevention and Rehabilitation, Heart Vascular Stroke Institute, Samsung Medical Center, Sungkyunkwan University School of Medicine, Seoul, Korea
[2]Department of Rehabilitation Medicine, College of Medicine, Chungnam National University, Daejeon, Korea
[3]Department of Rehabilitation Medicine, Konkuk University School of Medicine, Seoul, Korea
[4]Department and Research Institute of Rehabilitation Medicine, Yonsei University College of Medicine, Seoul, Korea
[5]Department of Rehabilitation Medicine, Pusan National University Yangsan Hospital, Yangsan, Korea
[6]Department of Preventive Medicine, Wonkwang University, School of Medicine, Iksan, Korea
[7]Department of Rehabilitation Medicine, Kyungpook National University Hospital, Daegu, Korea
[8]Department of Rehabilitation Medicine, Wonkwang University School of Medicine, Iksan, Korea
[9]Department of Rehabilitation Medicine, Jeju National University Hospital, Jeju National University School of Medicine, Jeju, Korea
[10]Department of Physical and Rehabilitation Medicine, Chonnam National University Medical School, Gwangju, Korea
[11]Department of Statistics, Hallym University, Chuncheon, Korea
[12]Department of Health Convergence, Ewha Womans University, Seoul, Korea
[13]Department of Physical and Rehabilitation Medicine, Sungkyunkwan University School of Medicine, Suwon, Korea
[14]Department of Health Science and Technology, Department of Medical Device Management and Research, SAIHST, Sungkyunkwan University, Seoul, Korea



**Received:** Feb 17, 2025
**Accepted:** Jul 15, 2025
**Published online:** Mar 12, 2026

**Address for Correspondence:**
**Won Hyuk Chang, MD, PhD**
Department of Physical and Rehabilitation Medicine, Center for Prevention and Rehabilitation, Heart Vascular Stroke Institute, Samsung Medical Center, Sungkyunkwan University School of Medicine, 115 Irwon-ro, Gangnam-gu, Seoul 06355, Republic of Korea.
Email: wh.chang@samsung.com

**Yun-Hee Kim, MD, PhD**
Department of Physical and Rehabilitation Medicine, Sungkyunkwan University School of Medicine, 2066 Seobu-ro, Jangan-gu, Suwon 16419, Republic of Korea.
Email: yunkim@skku.edu

*Current affiliation: Department of Physical Medicine and Rehabilitation, Chung-Ang University Hospital, Seoul, Korea



## ABSTRACT

**Background:** Updated data on stroke care trends are crucial for advancing stroke treatment. This study aimed to assess trends in inpatient care for first-ever stroke patients in South Korea over a 12-year period, focusing on demographic shifts and acute treatments including rehabilitation.

**Methods:** This multicenter cohort study analyzed first-ever stroke patients admitted to three representative hospitals in South Korea during 2008 (n = 911), 2014 (n = 1,489), and 2020 (n = 1,434). The 2008 data were collected retrospectively, while 2014 and 2020 data were obtained from a prospective cohort study. Data included demographics, risk factors, stroke characteristics, hospital course, and rehabilitation treatments.

**Results:** From 2008 to 2020, the mean age of stroke patients increased from 62.0 to 66.2 years. The proportion of ischemic stroke cases increased markedly from 47.3% to 74.5% while risk factors such as diabetes mellitus and hyperlipidemia showed increasing prevalence. Mechanical thrombectomy increased from 0% to 3.3%. Mean hospital stay decreased from 25.2 to 14.9 days, while in-hospital mortality declined from 5.9% to 3.7%. Rehabilitation consultations increased from 27.8% to 80.6%, occurring earlier during hospitalization. Rehabilitation therapy during hospitalization increased from 23.7% to 55.8%, and transfers to rehabilitation medicine rose from 12.8% to 19.1%. Home discharge increased from 34.8% to 60.0%.

**ORCID iDs**

Dae Hyun Kim
https://orcid.org/0000-0002-5065-4286
Min Kyun Sohn
https://orcid.org/0000-0002-2548-545X
Jongmin Lee
https://orcid.org/0000-0001-8718-0099
Deog Young Kim
https://orcid.org/0000-0001-7622-6311
Yong-Il Shin
https://orcid.org/0000-0001-7894-0930
Gyung-Jae Oh
https://orcid.org/0000-0001-9869-1564
Yang-Soo Lee
https://orcid.org/0000-0002-8855-1231
Min Cheol Joo
https://orcid.org/0000-0003-2778-4194
So Young Lee
https://orcid.org/0000-0002-2832-6083
Min-Keun Song
https://orcid.org/0000-0001-8186-5345
Junhee Han
https://orcid.org/0000-0001-5736-8752
Jeonghoon Ahn
https://orcid.org/0000-0002-0177-0192
Ho Seok Lee
https://orcid.org/0000-0002-3186-6005
Yun-Hee Kim
https://orcid.org/0000-0001-6101-8851
Won Hyuk Chang
https://orcid.org/0000-0002-4969-7895

**Funding**

This research was supported by the National Institute of Health (NIH) research project (project No.2025-E0901-00). The funder had no role in the study design, data collection, data analysis, data interpretation, or writing of the article.

**Disclosure**

The authors have no potential conflicts of interest to disclose.

**Author Contributions**

Conceptualization: Kim YH, Chang WH. Data curation: Kim DH, Sohn MK, Lee J, Kim DY, Shin Y, Oh G, Lee Y, Joo MC, Lee SY, Song M, Han J, Ahn J, Lee HS. Formal analysis: Kim DH, Chang WH. Funding acquisition: Kim YH, Chang WH. Methodology: Kim DH, Sohn MK, Lee J, Kim DY, Shin Y, Oh G, Lee Y, Joo MC, Lee SY, Song M, Han J, Ahn J, Lee HS. Supervision: Sohn MK, Lee J, Kim DY, Shin Y, Oh G, Lee Y, Joo MC, Lee SY, Song M, Han J, Ahn J, Lee HS. Visualization: Kim DH, Chang WH. Writing - original draft: Kim DH. Writing - review & editing: Kim YH, Chang WH.

**Conclusion:** Management of first-ever stroke patients in Korea improved substantially over 12 years, reflecting positive impacts of national quality initiatives and advancing stroke care.

**Keywords:** Stroke; Statistics; Epidemiology; Care; Rehabilitation; Korea

## INTRODUCTION

Stroke remains a significant global health concern, with recent data indicating its persistent impact. According to the 2023 American Heart Association statistical update, approximately 12.2 million incident stroke cases occurred globally in 2019, resulting in 143 million disability-adjusted life-years and 6.5 million deaths.[1,2] Stroke not only leads to significant mortality but also contributes to long-term disability, imposing a substantial economic burden on healthcare systems worldwide. Similarly, in South Korea, stroke is the fourth leading cause of death, and the absolute number of incident strokes increased by 29.7% from 2014 to 2019.[3] This rising incidence underscores the urgent need for effective prevention and management strategies.

Over the past few decades, South Korea has made significant advancements in stroke management to address this growing challenge. The introduction of intravenous thrombolysis, establishment of stroke units, and adoption of mechanical thrombectomy have substantially improved acute stroke care.[4,5] Concurrently, stroke rehabilitation has progressed with the implementation of comprehensive rehabilitation programs and early interventions, contributing to improved functional outcomes for stroke survivors.[6] Moreover, the Acute Stroke Quality Assessment Program (ASQAP) by the Health Insurance Review and Assessment Service has been instrumental in enhancing the quality of acute stroke care, promoting earlier initiation of rehabilitation, and reducing disparities among stroke hospitals. These collective efforts have led to encouraging outcomes, particularly a 12.8% reduction in stroke mortality from 2014 to 2020, despite the rising stroke incidence during the same period.[3]

Further improvements in stroke care require an understanding of how patient characteristics have changed over time to refine prevention and treatment strategies, predict future stroke burden, and enable proactive healthcare planning.[7,8] Although significant progress has been made, important gaps remain in our long-term understanding of stroke patient trends. Previous studies often focused on short-term observations, targeted specific aspects of stroke care without integrating rehabilitation data,[3,5] or relied on cross-sectional analyses,[4] limiting insights into the broader trajectory of stroke management.[9]

To address these gaps, our study provides a comprehensive perspective by analyzing data from the same three hospitals at three time points (2008, 2014, and 2020)—thus capturing 12-year longitudinal changes in acute stroke care and rehabilitation. This approach enables observation of the entire patient course, from admission through discharge, including initial treatments, inpatient care, interdepartmental consultations, and rehabilitation outcomes. By offering this holistic, longitudinal view, our work aims to fill critical gaps in knowledge regarding the evolution of stroke care in South Korea, providing essential insights for evidence-based policy-making to further enhance stroke prevention, management, and patient outcomes.

The purpose of this study is to comprehensively analyze the changes in acute stroke care and rehabilitation in South Korea over a 12-year period, from 2008 to 2020. Focusing on

three time points—2008, 2014, and 2020—we examine five key areas: 1) demographics, 2) risk factors, 3) stroke characteristics (types, subtypes, severity, and initial treatment), 4) hospital course (length of stay, mortality, and discharge destination), and 5) rehabilitation (consultation, transfer to a rehabilitation department, and discharge following comprehensive inpatient rehabilitation). These findings aim to guide future policy and practice, strengthening stroke prevention, acute treatment, and early rehabilitation in Korea.[4,5]

## METHODS

### Study design

This was a multicenter cohort study including retrospective data analyses from all patients with first-ever ischemic and hemorrhagic strokes admitted to three representative hospitals in South Korea during the calendar years of 2008, 2014, and 2020. These years were selected at six-year intervals to analyze temporal trends in stroke care and rehabilitation over a 12-year period.

### Data sources and collection

The 2008 data were collected retrospectively from electronic medical records, extracted from a larger dataset that included first-ever stroke patients from January 2008 to December 2009.[10] Only stroke patients admitted in 2008 were included in this study. In contrast, the 2014 and 2020 data were part of the Korean Stroke Cohort for Functioning and Rehabilitation (KOSCO), a prospective cohort study of first-ever stroke patients admitted to nine hospitals across South Korea. The detailed protocol for KOSCO was described elsewhere.[11] For the present analysis, only data from the same three hospitals (included in the 2008 dataset) were used in 2014 and 2020 for consistency. To standardize data collection, all variables and protocols were aligned across these datasets, and the data collectors received uniform training.

### Study participants

We identified all patients who admitted to the three hospitals with a diagnosis of stroke in 2008, 2014 and 2020. The inclusion criteria were 1) age 19 years or older; 2) first-ever acute stroke (ischemic or hemorrhagic stroke) with corresponding lesion evidence on computed tomography or magnetic resonance imaging; 3) admission within one week of stroke onset. Exclusion criteria were: 1) transient ischemic attack; 2) prior stroke history; 3) traumatic intracerebral hemorrhage (ICH); 4) non-Korean patients.

The number of included patients each year was 911 in 2008, 1,489 in 2014, and 1,434 in 2020. The distribution of patients across the hospitals was as follows:

- 2008: Samsung Medical Center (247 patients), Pusan National University Yangsan Hospital (206 patients), Chonnam National University Hospital (458 patients)
- 2014: Samsung Medical Center (477 patients), Pusan National University Yangsan Hospital (309 patients), Chonnam National University Hospital (703 patients)
- 2020: Samsung Medical Center (411 patients), Pusan National University Yangsan Hospital (321 patients), Chonnam National University Hospital (702 patients)

### Variables and measures

Data were categorized into five main domains: 1) patient demographics, 2) premorbid risk factors, 3) stroke characteristics, 4) hospital course and 5) rehabilitation. First, Patient demographics included age and gender. Second, Premorbid risk factors encompassed the


https://doi.org/10.3346/jkms.2026.41.e113

presence of hypertension, diabetes mellitus, hyperlipidemia, and atrial fibrillation. Third, stroke characteristics included stroke type (ischemic or hemorrhagic), subtypes, initial severity, and initial treatments. Ischemic stroke subtypes were classified according to the Trial of Org 10172 in Acute Stroke Treatment (TOAST) criteria and hemorrhagic stroke subtypes were subdivided into subarachnoid hemorrhage (SAH) and ICH. Initial severity was assessed using the Korean version of National Institute of Health Stroke Scale (K-NIHSS) for ischemic strokes[12] and Glasgow coma scale (GCS)[13] for hemorrhagic strokes. For subgroup analyses, ischemic strokes were dichotomized into mild (K-NIHSS ≤ 4) and moderate-to-severe (K-NIHSS ≥ 5) groups categories, and hemorrhagic strokes into mild (GCS 13–15) and moderate-to-severe (GCS ≤ 12).[14] Initial treatments for ischemic strokes included intravenous tissue plasminogen activator administration and mechanical thrombectomy, while for hemorrhagic strokes, they included aneurysm clipping, aneurysm coiling, burr hole drainage, and hematoma aspiration. Fourth, hospital course covered length of hospital stay, complications, in-hospital mortality rates, and discharge destination. Fifth, rehabilitation included various aspects such as rehabilitation consultation, time to consultation, rehabilitation during hospitalization, transfer to the department of rehabilitation medicine for the comprehensive rehabilitation, and discharge.

### Statistical analyses

All statistical analyses were conducted using Prism (version 10.2.3; GraphPad Software, San Diego, CA, USA). Numerical variables were compared across the three time points (2008, 2014 and 2020) using one-way analysis of variance (ANOVA). When the ANOVA revealed significant differences ($P < 0.05$), post-hoc analyses were performed using independent *t*-tests with Tukey correction for multiple comparisons. Categorical variables were analyzed using $\chi^2$ tests or Fisher's exact tests, to identify significant differences among the three time points. For variables showing significant differences, multiple comparisons with Bonferroni correction were conducted. For severity-stratified analyses, the same statistical methods were applied within each severity subgroup (mild and moderate-to-severe) to assess temporal changes across the three time points. A *P* value of less than 0.05 was considered statistically significant.

### Ethics statement

This study was approved by the Institutional Review Board (IRB) of each participating hospital. For the 2008 cohort, retrospective data collection was approved by the IRB of each participating hospital, and the requirement for informed consent was waived due to the retrospective nature of the study. For the 2014 and 2020 cohorts, the study protocol was reviewed and approved by the IRB of each participating hospital, and written informed consent was obtained from all patients prior to inclusion in the study (IRB No. Samsung Medical Center, 2019-11-095, 2012-06-016; Pusan National University Yangsan Hospital, 04-2019-034, 05-2012-057; Chonnam National University Hospital, CNUH-2020-008, CNUH-2012-127).

## RESULTS

### Patient demographic

The mean age of all stroke patients increased significantly over the study period, from 62.0 ± 14.2 years in 2008 to 64.3 ± 13.7 years in 2014 (2008 vs. 2014: $P < 0.001$), and further to 66.2 ± 13.4 years in 2020 (2008 vs. 2020: $P < 0.0001$; 2014 vs. 2020: $P < 0.001$). Detailed age distribution analysis revealed significant shifts in stroke occurrence patterns across different age groups (**Fig. 1A**). There was a notable rise in the proportion of patients aged


https://doi.org/10.3346/jkms.2026.41.e113

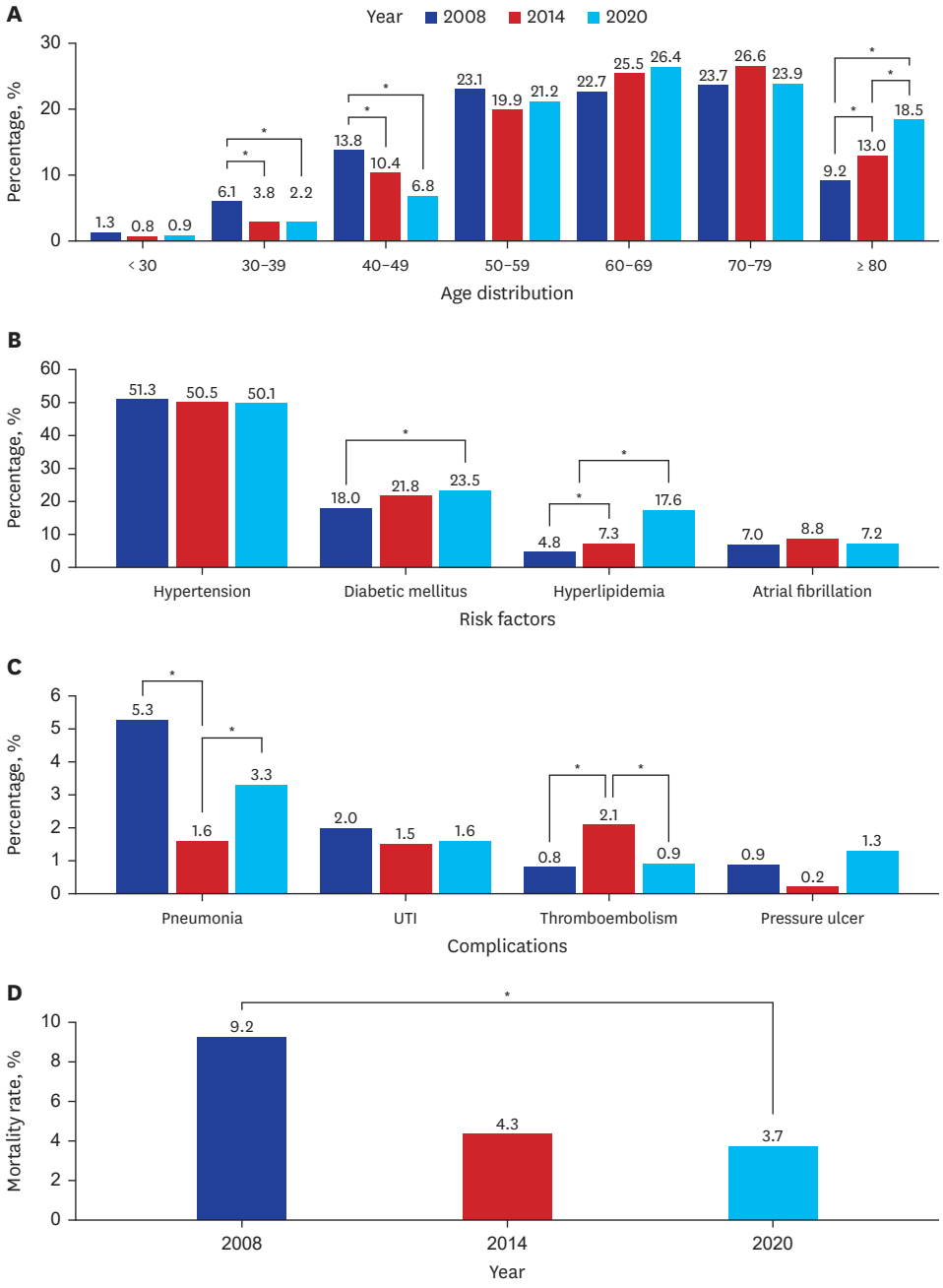


**Fig. 1.** Stroke characteristics and hospital course. (**A**) Age distribution across all periods. (**B**) Temporal changes in risk factors. (**C**) Changes in in-hospital complications. (**D**) Annual mortality rates.
Statistical significance markers: $^{*}P < 0.05$.

≥ 80 years, whereas younger age brackets (e.g., 30–39 and 40–49 years) decreased, reflecting an aging stroke population. The middle-aged groups (50-79 years) showed relatively stable distributions, with slight fluctuations over the 12-year period. The proportion of male patients varied minimally (55.3–58.8%), without statistical significance (**Table 1**).

*Ischemic stroke patients*

The mean age showed a non-linear trend, starting at 66.7 ± 13.0 years in 2008, decreasing slightly to 65.7 ± 13.3 years in 2014, and then significantly increasing to 68.4 ± 12.6 years in


https://doi.org/10.3346/jkms.2026.41.e113

**Table 1.** Characteristics and outcomes of total stroke patients across three time periods

| Variables | Year | | |
|---|---|---|---|
| | 2008 (n = 911) | 2014 (n = 1,489) | 2020 (n = 1,434) |
| Demographic | | | |
| Sex, male | 504 (55.3) | 875 (58.8) | 820 (57.2) |
| Age, yr[a,b,c] | 62.0 ± 14.2 | 64.3 ± 13.7 | 66.2 ± 13.4 |
| Risk factors | | | |
| Hypertension | 468 (51.3) | 752 (50.5) | 719 (50.1) |
| Diabetes mellitus[c] | 164 (18.0) | 324 (21.8) | 337 (23.5) |
| Hyperlipidemia[a,b,c] | 44 (4.8) | 109 (7.3) | 253 (17.6) |
| Atrial fibrillation | 64 (7.0) | 131 (8.8) | 103 (7.2) |
| Stroke type | | | |
| Infarction:Hemorrhage[a,c] | 431 (47.3):480 (52.7) | 1,164 (78.2):325 (21.8) | 1,069 (74.5):365 (25.5) |
| Hospital course | | | |
| Hospital stay, day[a,c] | 25.2 ± 36.5 | 16.1 ± 20.3 | 14.9 ± 21.1 |
| Mortality[a,c] | 84 (9.2) | 64 (4.3) | 53 (3.7) |
| Discharge destination | | | |
| Home[a,c] | 317 (34.8) | 923 (62.0) | 870 (60.7) |
| Rehabilitation | | | |
| Consultation[a,b,c] | 253 (27.8) | 1,084 (72.8) | 1,156 (80.6) |
| Consultation time, day[a,c] | 10.3 ± 12.9 | 2.5 ± 4.7 | 2.0 ± 11.1 |
| Rehabilitation treatment[a,c] | 216 (23.7) | 828 (55.6) | 801 (55.8) |
| Transfer[b,c] | 117 (12.8) | 204 (13.7) | 274 (19.1) |
| Transfer time, day[a,c] | 29.1 ± 47.5 | 16.7 ± 11.6 | 12.3 ± 10.0 |
| Hospital stay in RM, day[b] | 25 ± 18.1 | 30.9 ± 27.9 | 21.9 ± 13.2 |
| Discharge to home after RM[b,c] | 37 (31.6) | 69 (33.8) | 120 (43.8) |

Values are presented as number (%) or mean ± standard deviation.
RM = rehabilitation medicine department.
[a]2008 vs. 2014 corrected $P < 0.05$, [b]2014 vs. 2020 corrected $P < 0.05$, [c]2008 vs. 2020 corrected $P < 0.05$.

2020 (2014 vs. 2020: $P < 0.001$). The male proportion remained around 60% of patients across all time points (**Table 2**).

*Hemorrhagic stroke patients*

The mean age increased slightly from 57.7 ± 13.9 years in 2008 to 59.8 ± 13.4 years in 2020; however, this change was not statistically significant. The male-to-female ratio remained around 50% of patients across all time points (**Table 3**).

## Premorbid risk factors

Among all stroke patients, hypertension stayed around 50%, while diabetes mellitus significantly increased from 18.0% in 2008 to 23.5% in 2020 ($P = 0.002$). Hyperlipidemia showed the most pronounced increase, rising from 4.8% in 2008 to 7.3% in 2014 (2008 vs. 2014: $P = 0.015$), and further to 17.6% in 2020 (2008 vs. 2020 and 2014 vs. 2020: $P < 0.001$). Atrial fibrillation remained relatively stable, ranging from 7.0% to 8.8% (**Fig. 1B**).

*Ischemic stroke patients*

Hypertension decreased significantly from 59.3% in 2008 to 52.6% in 2020 (2008 vs. 2020: $P = 0.016$). Diabetes mellitus remained stable at around 25-26%. Hyperlipidemia markedly increased from 8.1% in 2008 and 8.8% in 2014 to 19.8% in 2020 (2008 vs. 2020 and 2014 vs. 2020: $P < 0.001$). Atrial fibrillation tended to decrease slightly from 13.0% in 2008 to 9.3% in 2020 though not statistically significant.

*Hemorrhagic stroke patients*

Hypertension remained stable at around 42–43%. Diabetes mellitus increased modestly (11.4% to 14.5%), and hyperlipidemia increased significantly from 1.9% in 2008 and 2.2% in


https://doi.org/10.3346/jkms.2026.41.e113

**Table 2.** Characteristics and outcomes of ischemic stroke patients across three time periods

| Variables | Year | | |
|---|---|---|---|
| | 2008 (n = 431) | 2014 (n = 1,164) | 2020 (n = 1,069) |
| Demographic | | | |
| Sex, male | 259 (60.2) | 705 (60.6) | 650 (60.8) |
| Age, yr[a] | 66.7 ± 13.0 | 65.7 ± 13.3 | 68.4 ± 12.6 |
| Risk factors | | | |
| Hypertension[b] | 256 (59.3) | 617 (53.0) | 562 (52.6) |
| Diabetes mellitus | 109 (25.3) | 288 (24.7) | 284 (26.6) |
| Hyperlipidemia[a,b] | 35 (8.1) | 102 (8.8) | 212 (19.8) |
| Atrial fibrillation | 56 (13.0) | 124 (10.7) | 99 (9.3) |
| TOAST classification | | | |
| Large artery atherosclerosis[a,c] | 261 (60.6) | 573 (49.2) | 608 (56.9) |
| Small vessel occlusion[c] | 66 (15.3) | 246 (21.1) | 219 (20.5) |
| Cardioembolic[a,c] | 61 (14.2) | 238 (20.5) | 130 (12.2) |
| Other determined[b,c] | 14 (3.2) | 80 (6.9) | 69 (6.4) |
| Undetermined[c] | 29 (6.7) | 27 (2.3)[b,c] | 43 (4.0) |
| Initial K-NIHSS[a,b,c] | 7.5 ± 6.3 | 5.7 ± 5.8 | 4.7 ± 5.2 |
| Initial treatment | | | |
| Intravenous thrombolysis[a] | 61 (14.1) | 127 (10.9) | 155 (14.5) |
| Mechanical thrombectomy[a,b] | 0 (0.0) | 9 (0.7) | 36 (3.3) |
| Hospital course | | | |
| Hospital stay, day[b,c] | 22.1 ± 41.4 | 13.6 ± 15.6 | 12.5 ± 21.1 |
| Mortality[b] | 23 (5.3) | 32 (2.8) | 20 (1.9) |
| Discharge destination | | | |
| Home[b,c] | 168 (39.0) | 776 (66.7) | 737 (68.9) |
| Rehabilitation | | | |
| Consultation[b,c] | 134 (31.1) | 908 (78.0) | 864 (80.8) |
| Consultation time, day[a,b,c] | 6.8 ± 5.9 | 2.0 ± 3.2 | 1.5 ± 2.6 |
| Rehabilitation treatment[b,c] | 111 (25.7) | 699 (60.0) | 591 (55.2) |
| Transfer[a,b] | 42 (9.7) | 135 (11.6) | 196 (18.3) |
| Transfer time, day[a,b,c] | 20.1 ± 22.6 | 14.5 ± 10.6 | 9.5 ± 5.7 |
| Hospital stay in RM, day[a,b] | 28.0 ± 24.1 | 27.4 ± 18.8 | 19.8 ± 12.1 |
| Discharge to home after RM[b] | 11 (26.1) | 52 (38.5) | 91 (46.4) |

Values are presented as number (%) or mean ± standard deviation.
TOAST = Trial of ORG 10172 in Acute Stroke Treatment, K-NIHSS = Korean version of National Institutes of Health Stroke Scale, RM = rehabilitation medicine department.
[a]2014 vs. 2020 corrected $P < 0.05$, [b]2008 vs. 2020 corrected $P < 0.05$, [c]2008 vs. 2014 corrected $P < 0.05$.

2014 to 11.2% in 2020 (2008 vs. 2020 and 2014 vs. 2020: $P < 0.001$). Atrial fibrillation stayed low at 1.1–2.2%.

## Stroke characteristics

### *Stroke type*

The proportion of ischemic stroke increased significantly from 47.3% in 2008 to 78.2% in 2014 and 74.5% in 2020 (2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$). The absolute number of ischemic stroke patients was 431 in 2008, 1,164 in 2014, and 1,069 in 2020. In contrast, the number of hemorrhagic stroke patients was 480 in 2008, 325 in 2014, and 365 in 2020 (**Table 1** and **Fig. 2**).

### *Stroke subtype*

Using TOAST classification for ischemic stroke patients, large artery atherosclerosis showed fluctuation (60.6% in 2008, 49.2% in 2014, 56.9% in 2020, 2008 vs. 2014: $P < 0.001$; 2014 vs. 2020: $P < 0.001$). Small vessel occlusion (SVO) increased from 15.3% in 2008 to 20.5% in 2020 (2008 vs. 2014: $P = 0.034$). Cardioembolic strokes showed a non-linear trend, increasing from 14.2% in 2008 to 20.5% in 2014, then decreasing to 12.2% in 2020 (2008 vs. 2014: $P = 0.004$; 2014 vs. 2020: $P < 0.001$, **Table 2**).


https://doi.org/10.3346/jkms.2026.41.e113

**Table 3.** Characteristics and outcomes of hemorrhagic stroke patients across three time periods

| Variables | Year | | |
|---|---|---|---|
| | 2008 (n = 480) | 2014 (n = 325) | 2020 (n = 365) |
| Demographic | | | |
| Sex, male | 245 (51.0) | 170 (52.3) | 170 (46.6) |
| Age | 57.7 ± 13.9 | 59.4 ± 13.8 | 59.8 ± 13.4 |
| Risk factors | | | |
| Hypertension | 212 (42.0) | 135 (41.5) | 157 (43.0) |
| Diabetes mellitus | 55 (11.4) | 36 (11.1) | 53 (14.5) |
| Hyperlipidemia[a,b] | 9 (1.9) | 7 (2.2) | 41 (11.2) |
| Atrial fibrillation | 8 (1.7) | 7 (2.2) | 4 (1.1) |
| Subtype | | | |
| Subarachnoid hemorrhage | 229 (47.7) | 148 (45.5) | 181 (49.6) |
| Intracerebral hemorrhage | 202 (42.1) | 159 (48.9) | 168 (46.0) |
| Initial GCS | 11.8 ± 3.8 | 11.7 ± 3.8 | 12.1 ± 3.8 |
| Initial treatment | | | |
| Aneurysm clipping | 113 (23.5) | 73 (22.5) | 69 (18.9) |
| Aneurysm coiling[a] | 75 (15.6) | 34 (10.4) | 63 (17.2) |
| Burr hole drainage[a,b] | 17 (3.5) | 3 (0.9) | 32 (8.7) |
| Hematoma aspiration[b,c] | 89 (18.5) | 18 (5.5) | 39 (10.7) |
| Hospital course | | | |
| Hospital stay, day[b] | 28.1 ± 31.0 | 25.1 ± 30.3 | 22.1 ± 19.5 |
| Mortality[b] | 61 (12.7) | 32 (9.9) | 33 (9.0) |
| Discharge destination | | | |
| Home[b,c] | 149 (31.0) | 147 (45.2) | 133 (36.4) |
| Rehabilitation | | | |
| Consultation[a,b,c] | 119 (24.8) | 176 (54.2) | 292 (80.0) |
| Consultation time, day[a,b] | 13.9 ± 16.7 | 4.8 ± 8.6 | 3.3 ± 21.6 |
| Rehabilitation treatment[a,b,c] | 105 (21.8) | 129 (39.6) | 210 (57.5) |
| Transfer | 75 (15.6) | 69 (21.2) | 78 (21.3) |
| Transfer time, day[b] | 33.8 ± 56.1 | 21.1 ± 12.1 | 19.3 ± 14.3 |
| Hospital stay in RM, day[a,c] | 23.3 ± 13.7 | 37.7 ± 39.4 | 27.0 ± 14.4 |
| Discharge to home after RM | 26 (34.6) | 17 (24.6) | 29 (37.2) |

Values are presented as number (%) or mean ± standard deviation.
GCS = Glasgow Coma Scale, RM = rehabilitation medicine department.
[a]2014 vs. 2020 corrected $P < 0.05$, [b]2008 vs. 2020 corrected $P<0.05$, [c]2008 vs. 2014 corrected $P < 0.05$.

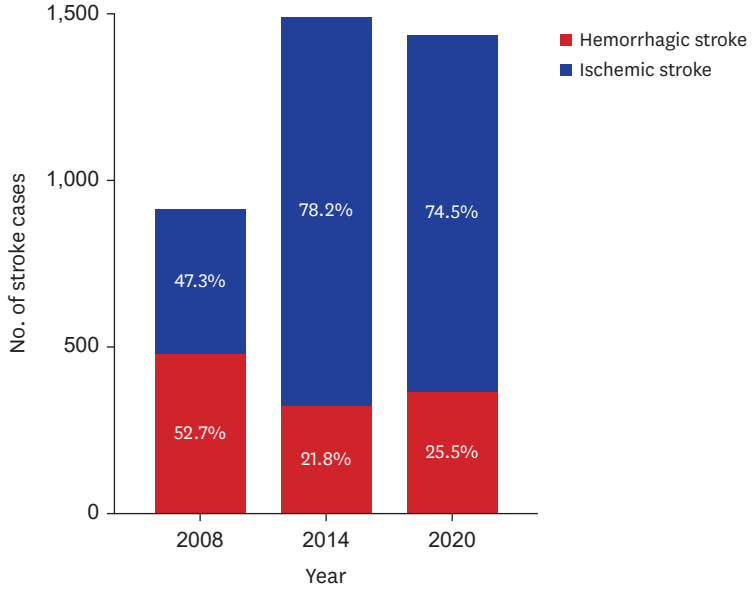


**Fig. 2.** Temporal changes in stroke type distribution. Bar graph showing changes in the distribution of stroke types over the study period. The y-axis represents the absolute number of patients. Blue bars represent ischemic strokes and red bars represent hemorrhagic strokes. Numbers inside bars indicate the percentage of each stroke type.


https://doi.org/10.3346/jkms.2026.41.e113

For hemorrhagic strokes, the proportion of SAH (45.5–49.6%) and ICH (42.1–48.9%) remained relatively stable.

*Initial severity and treatment*

The mean K-NIHSS for ischemic strokes decreased significantly from 7.5 ± 6.3 in 2008 to 5.7 ± 5.8 in 2014, and further to 4.7 ± 5.2 in 2020 ($P < 0.001$ for all comparisons). The mean GCS for hemorrhagic strokes remained stable (11.8 ± 3.8 to 12.1 ± 3.8).

For ischemic strokes, intravenous thrombolysis fluctuated (14.1% to 14.5%) while mechanical thrombectomy increased from 0% in 2008 to 0.7% in 2014, and further to 3.3% in 2020 (2008 vs. 2020 and 2014 vs. 2020: $P < 0.001$). In hemorrhagic stroke patients, aneurysm coiling increased significantly (10.4% in 2014 to 17.2% in 2020, $P = 0.012$) while clipping rates showed a slight decrease (23.5% to 18.9%).

## Hospital course

*Length of hospital stay and complications*

Mean hospital stay decreased significantly across all stroke types (25.2 ± 36.5 to 14.9 ± 21.1 days, 2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$). The reduction was observed in both ischemic (22.1 ± 41.4 to 12.5 ± 21.1 days, 2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$) and hemorrhagic strokes (28.1 ± 31.0 to 22.1 ± 19.5 days in 2020, 2008 vs. 2020: $P = 0.005$). When stratified by severity, mean hospital stay in mild subgroups decreased significantly in both ischemic (15.9 ± 31.6 to 9.7 ± 22.5 days, $P < 0.001$ for all comparisons) and hemorrhagic strokes (25.1 ± 25.7 to 19.5 ± 15.9 days, 2008 vs. 2020: $P = 0.001$). In contrast, the moderate-to-severe subgroups in both ischemic and hemorrhagic strokes showed decreasing trends that did not reach statistical significance (**Tables 4** and **5**).

Overall complication rates remained low. Pneumonia showed significant variations (5.3% to 3.3%), as did thromboembolism (0.8% to 0.9%, with a peak of 2.1% in 2014). Other complications maintained stable, low rates throughout all period (**Fig. 1C** and **Supplementary Table 1**).

*Mortality and discharge outcome*

In-hospital mortality decreased significantly from 9.2% to 3.7% (2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$, **Fig. 1D**). This decline was more pronounced in ischemic strokes (5.3% to 1.9%) compared to hemorrhagic strokes (12.7% to 9.0%). When stratified by severity, mortality rates showed a decreasing trend in both mild and moderate-to-severe ischemic stroke subgroups, while hemorrhagic stroke mortality exhibited non-linear patterns with no statistically significant changes across all severity levels. Analysis of mortality causes showed that direct stroke-related deaths increased over time in both types, more notably in ischemic strokes (47.8% to 70.0%) than hemorrhagic strokes (70.5% to 81.8%). Mean time to mortality shortened significantly in hemorrhagic strokes (19.4 ± 40.0 to 7.2 ± 8.3 days) while remaining variable in ischemic strokes (38.8 ± 92.2 to 31.2 ± 102.0 days).

Home discharge rates increased substantially from 34.8% in 2008 to 62.0% in 2014 and remained stable at 60.7% in 2020 (2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$), with ischemic stroke patients showing higher rates (68.9% in 2020) compared to hemorrhagic stroke patients (36.4% in 2020). When stratified by severity, both mild (62.9% to 81.3%, $P < 0.001$ for all comparisons) and moderate-to-severe (23.4% to 43.9%, 2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$) subgroups in ischemic stroke showed significant increase in home discharge rates. For hemorrhagic stroke, the mild subgroup showed significant increase from 40.1% in


https://doi.org/10.3346/jkms.2026.41.e113

**Table 4.** Hospital course and rehabilitation in ischemic stroke patients according to initial severity

| Variables | Year | | |
|---|---|---|---|
| | 2008 (n = 431) | 2014 (n = 1,164) | 2020 (n = 1,069) |
| Mild group | n = 170 | n = 670 | n = 716 |
| Hospital course | | | |
| Hospital stay, day[a,b,c] | 15.9 ± 31.6 | 10.4 ± 11.8 | 9.7 ± 22.5 |
| Mortality | 2 (1.2) | 1 (0.1) | 1 (0.1) |
| Discharge destination | | | |
| Home[a,c] | 107 (62.9) | 553 (82.5) | 582 (81.3) |
| Rehabilitation | | | |
| Consultation[a,b,c] | 35 (20.6) | 475 (70.9) | 556 (77.7) |
| Consultation time, day[a,b,c] | 6.0 ± 5.5 | 1.8 ± 2.2 | 1.3 ± 2.0 |
| Rehabilitation treatment[a,c] | 30 (17.6) | 325 (48.5) | 340 (47.5) |
| Transfer[c] | 9 (5.3) | 34 (5.1) | 85 (11.9) |
| Transfer time, day[b] | 15.2 ± 14.4 | 13.3 ± 13.1 | 8.4 ± 5.0 |
| Hospital stay in RM, day[b] | 19.7 ± 12.3 | 27.3 ± 16.7 | 16.8 ± 7.5 |
| Discharge to home after RM | 2 (22.2) | 14 (41.2) | 52 (61.2) |
| Moderate to severe group | n = 261 | n = 494 | n = 353 |
| Hospital course | | | |
| Hospital stay, day | 26.1 ± 46.4 | 18.4 ± 18.6 | 18.1 ± 16.7 |
| Mortality | 21 (8.0) | 31 (6.3) | 19 (5.4) |
| Discharge destination | | | |
| Home[a,c] | 61 (23.4) | 223 (45.1) | 155 (43.9) |
| Rehabilitation | | | |
| Consultation[a,c] | 99 (37.9) | 433 (87.7) | 308 (87.3) |
| Consultation time, day[a,b,c] | 7.1 ± 6.0 | 2.2 ± 3.9 | 2.0 ± 3.5 |
| Rehabilitation treatment[a,c] | 81 (31.0) | 374 (75.7) | 251 (71.1) |
| Transfer[a,b,c] | 33 (12.6) | 101 (20.4) | 111 (31.4) |
| Transfer time, day[b,c] | 26.5 ± 36.7 | 14.9 ± 9.7 | 10.3 ± 6.0 |
| Hospital stay in RM, day[b] | 27.7 ± 26.5 | 27.4 ± 19.5 | 22.2 ± 14.3 |
| Discharge to home after RM | 9 (27.3) | 38 (37.6) | 39 (35.1) |

Values are presented as number (%) or mean ± standard deviation.
Mild group was defined as the Korean version of National Institute of Health Stroke Scale ≤ 4 and moderate-to-severe group as the Korean version of National Institute of Health Stroke Scale ≥ 5.
RM = rehabilitation medicine department.
[a]2008 vs. 2014 corrected $P < 0.05$, [b]2014 vs. 2020 corrected $P < 0.05$, [c]2008 vs. 2020 corrected $P < 0.05$.

2008 to 57.9% in 2014 ($P = 0.001$), while the moderate-to-severe group showed a concerning decrease from 28.9% in 2014 to 12.6% in 2020 ($P = 0.007$). Transfers to rehabilitation facilities remained stable (4.5% to 5.2%), while discharges to other facilities decreased significantly (28.6% to 4.9%).

## Rehabilitation

### *Consultation and treatment*

Rehabilitation consultation rates increased markedly from 27.8% in 2008 to 72.8% in 2014 and 80.6% in 2020 ($P < 0.001$ for all comparisons), with consultation time decreasing from 10.3 ± 12.9 to 2.0 ± 11.1 days (**Fig. 3A**). This improvement was observed in both stroke types. When stratified by severity, similar significant improvements were observed across all subgroups. For mild ischemic stroke, consultation rates increased from 20.6% to 77.7% and consultation time decreased from 6.0 to 1.3 days ($P < 0.001$ for all comparisons).
In moderate-to-severe ischemic stroke, consultation rates rose from 37.9% to 87.3% (2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$) with consultation time decreasing from 7.1 to 2.0 days (2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$, 2014 vs. 2020; $P = 0.003$). For hemorrhagic stroke, both mild (20.2% to 77.2%) and moderate-to-severe (31.0% to 85.7%) subgroups showed significant increases in consultation rates and decreases in consultation time (2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$).


https://doi.org/10.3346/jkms.2026.41.e113

**Table 5.** Hospital course and rehabilitation in hemorrhagic stroke patients according to initial severity

| Variables | Year | | |
|---|---|---|---|
| | 2008 (n = 480) | 2014 (n = 325) | 2020 (n = 365) |
| Mild group | n = 277 | n = 183 | n = 246 |
| Hospital course | | | |
| Hospital stay, day[a] | 25.1 ± 25.7 | 22.7 ± 20.5 | 19.5 ± 15.9 |
| Mortality | 12 (4.3) | 4 (2.2) | 6 (2.4) |
| Discharge destination | | | |
| Home[b] | 111 (40.1) | 106 (57.9) | 118 (48.0) |
| Rehabilitation | | | |
| Consultation[a,b,c] | 56 (20.2) | 106 (57.9) | 190 (77.2) |
| Consultation time, day[a,b] | 12.0 ± 14.0 | 3.7 ± 5.6 | 3.9 ± 26.7 |
| Rehabilitation treatment[a,b] | 49 (17.7) | 77 (42.1) | 127 (51.6) |
| Transfer[b] | 33 (11.9) | 39 (21.3) | 45 (18.3) |
| Transfer time, day | 22.8 ± 16.3 | 18.5 ± 10.8 | 16.7 ± 13.2 |
| Hospital stay in RM, day[c] | 20.3 ± 12.3 | 31.9 ± 21.2 | 23.8 ± 13.2 |
| Discharge to home after RM[c] | 12 (36.4) | 9 (23.1) | 23 (51.1) |
| Moderate to severe group | n = 203 | n = 142 | n = 119 |
| Hospital course | | | |
| Hospital stay, day | 32.2 ± 36.7 | 28.2 ± 39.3 | 27.4 ± 24.6 |
| Mortality | 49 (24.1) | 28 (19.7) | 27 (22.7) |
| Discharge destination | | | |
| Home[c] | 38 (18.7) | 41 (28.9) | 15 (12.6) |
| Rehabilitation | | | |
| Consultation[a,b,c] | 63 (31.0) | 70 (49.3) | 102 (85.7) |
| Consultation time, day[a,b] | 15.5 ± 18.8 | 6.5 ± 11.7 | 2.3 ± 4.1 |
| Rehabilitation treatment[a,c] | 56 (27.6) | 52 (36.6) | 83 (69.7) |
| Transfer | 42 (20.7) | 30 (21.1) | 33 (27.7) |
| Transfer time, day | 41.8 ± 72.0 | 24.5 ± 12.9 | 23.0 ± 15.3 |
| Hospital stay in RM, day[a,c] | 23.6 ± 15.6 | 45.3 ± 54.3 | 31.5 ± 15.0 |
| Discharge to home after RM | 14 (33.3) | 8 (26.7) | 6 (18.2) |

Values are presented as number (%) or mean ± standard deviation.
Mild group was defined as Glasgow coma scale 13–15 and moderate-to-severe group as Glasgo coma scale ≤ 12.
[a]2008 vs. 2020 corrected $P < 0.05$, [b]2008 vs. 2014 corrected $P < 0.05$, [c]2014 vs. 2020 corrected $P < 0.05$.

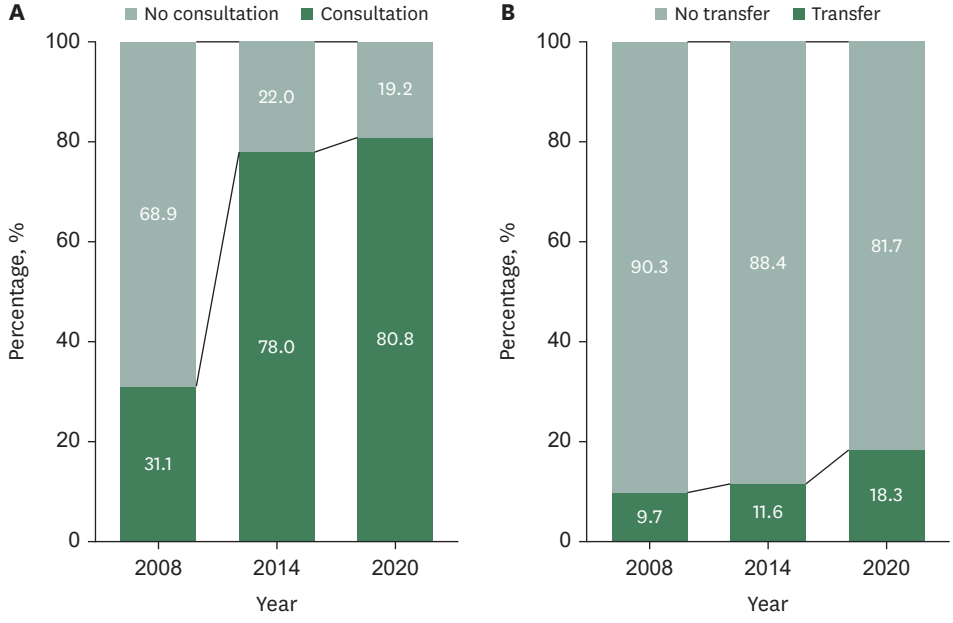


**Fig. 3.** Temporal changes of rehabilitation care. (**A**) Changes in rehabilitation consultation rates. (**B**) Transfer rates. Green shades represent different categories; numbers indicate percentages; lines show temporal trends.


https://doi.org/10.3346/jkms.2026.41.e113

The proportion of patients receiving rehabilitation during acute care increased significantly from 23.7% in 2008 to 55.6% in 2014 and 55.8% in 2020 (2008 vs. 2014 and 2008 vs. 2020: $P < 0.001$). Severity-stratified analysis revealed consistent improvements in all subgroups. Analysis of specific rehabilitation services showed increased utilization of physical therapy (bedside: 4.3% to 12.4%; regular: 9.4% to 19.3%) and occupational therapy (5.9% to 18.6%, **Supplementary Table 2**).

*Comprehensive rehabilitation*

Transfer rates to rehabilitation medicine departments increased from 12.8% in 2008 to 13.7% in 2014 and 19.1% in 2020 (2008 vs. 2020 and 2014 vs. 2020: $P < 0.001$), with significantly reduced transfer times from 29.1 to 12.3 days (**Fig. 3B**). When stratified by severity, the moderate-to-severe subgroup in ischemic stroke showed the most substantial improvement in transfer rates (12.6% to 31.4%, 2008 vs. 2014: $P = 0.0307$; 2014 vs. 2020: $P = 0.001$; 2008 vs. 2020: $P < 0.001$) and transfer times (26.5 to 10.3 days, 2008 vs. 2020: $P = 0.002$; 2014 vs. 2020: $P < 0.001$).

Length of stay in rehabilitation decreased from 30.9 days in 2008 to 14.5 days in 2014 and 9.5 days in 2020 (2008 vs. 2014: $P < 0.001$, 2008 vs. 2020 and 2014 vs. 2020: $P < 0.001$), while home discharge rates after rehabilitation improved from 31.6% to 43.8%. When stratified by severity, length of stay in rehabilitation decreased significantly from 2014 to 2020 in both mild (27.3 to 16.8 days, $P = 0.001$) and moderate-to-severe ischemic stroke (27.4 to 22.2 days, $P = 0.024$).

Patients transferred to rehabilitation departments received more comprehensive services, including higher rates of specialized therapies compared to consultation-only patients: occupational therapy (41.6% vs. 18.6% in 2020), speech-language therapy (14.6% vs. 2.9%), dysphagia therapy (11.3% vs. 1.9%), and cognitive therapy (10.6% vs. 0.5%). This pattern was consistent across both stroke types, though transfer timing and outcomes showed some variations between ischemic and hemorrhagic strokes (**Supplementary Table 2**).

## DISCUSSION

This study provides a comprehensive analysis of trends in stroke characteristics and management in South Korea over a 12-year period (2008–2020). One of the most notable findings is the significant increase in ischemic strokes, from 47.3% in 2008 to 74.5% in 2020, driven by a marked rise in the absolute number of ischemic cases, whereas hemorrhagic stroke remained relatively constant. This observation aligns with patterns seen in other Korean epidemiological studies. Kim et al.[15] reported that among 19,608 patients treated in 216 hospitals during 2013–2014, 76% had ischemic stroke, supporting our observed trend. More recently, Shin et al.[16] reported that 74.9% of strokes were ischemic during 2016–2021, further confirming this evolving pattern. This observation aligns with patterns seen in other developed countries undergoing epidemiological transition.[2] Although population aging and the expanding burden of modifiable risk factors (e.g., hypertension, diabetes, hyperlipidemia) partially explain this trend, our data also point to increased detection of mild or very mild ischemic strokes—which may reflect improvements in diagnostic capabilities and increased public awareness.[17,18] Advances in neuroimaging technologies, such as diffusion-weighted imaging, have significantly increased the detection of smaller ischemic lesions and facilitated differentiation from stroke mimics. In South Korea, public awareness

campaigns have effectively educated the population about stroke symptoms and the importance of prompt medical attention, leading to increased emergency department visits for even minor symptoms.[18,19] The mean K-NIHSS scores for ischemic stroke decreased, underscoring the growing proportion of less severe strokes at presentation—a finding consistent with other large-scale stroke registries such as the Japan Stroke Data Bank.[20,21] Moreover, the significant rise in hyperlipidemia and diabetes highlights westernized lifestyle factors, potentially influencing stroke subtypes and contributing to increasing SVO.[2,22] Overall, these data suggest that demographic changes, metabolic risk factor increases, and enhanced stroke detection efforts collectively contribute to the observed rise in ischemic stroke incidence and the concurrent decline in initial stroke severity.

A second key finding is the advancement of acute stroke treatment strategies over time, reflecting both technological progress and adaptations to clinical guidelines. In ischemic stroke cases, mechanical thrombectomy—initially not performed in our earliest data—gained increasing acceptance in subsequent years, paralleling growing evidence of its efficacy and the introduction of national insurance coverage in August 2014.[4,23,24] For hemorrhagic stroke, the increasing preference for endovascular coiling aligns with global and domestic trends favoring minimally invasive interventions. These overall trends align with both international and domestic reports, which highlight expanding procedural expertise and a collective preference for less invasive techniques.[25,26] These observations highlight how emerging clinical evidence, policy reforms, and technological innovation have collectively enhanced early stroke management in Korea, reinforcing the validity of our findings and offering insights for ongoing improvements.

A third major finding of our study relates to the broader impact of evolving stroke care on clinical outcomes, including hospital course, in-hospital complications, and mortality. Over the 12-year period, stroke patients experienced shorter hospital stays and a noteworthy decrease in overall in-hospital mortality, suggesting improved acute management.[27] Importantly, our severity-stratified analyses demonstrate that these improvements were not confined to milder cases. While length-of-stay reductions were most pronounced in mild ischemic stroke, significant improvements were also observed in mild hemorrhagic stroke, with parallel decreasing trends in their moderate-to-severe counterparts. Similarly, mortality showed favorable trends across severity levels for ischemic stroke, though severe hemorrhagic stroke continues to present challenges with persistently high mortality. Interestingly, the proportion of deaths directly attributable to stroke increased over time in both stroke types, which may reflect better management of preventable complications while mortality from severe neurological damage persisted. Home discharge rates improved significantly in both mild and moderate-to-severe ischemic stroke, with the latter group showing particularly substantial gains (23.4% to 43.9%), confirming that enhanced care systems benefited patients across the severity spectrum. Although specific complications such as pneumonia and thromboembolism showed occasional fluctuations, their overall rates remained relatively low, reflecting effective acute care protocols even amidst an aging patient population.[28] These improvements are consistent with the synergy between national quality initiatives (e.g., ASQAP) and advances in clinical practice, supporting the development of a more efficient stroke care system in Korea.[29] The severity-stratified analyses confirm that while severity shifts contributed partially to overall outcome improvements, substantial quality gains occurred independent of case-mix changes, particularly for moderate-to-severe ischemic strokes.


https://doi.org/10.3346/jkms.2026.41.e113

Over the 12-year study period, we also observed a marked expansion in rehabilitation services for acute stroke patients. Consultation rates rose dramatically, time to consultation dropped to within roughly two days of admission, and many more patients received therapy during their acute stay. Our severity-stratified analyses confirm that these improvements occurred across the entire severity spectrum, not merely among milder cases. Particularly noteworthy was the substantial increase in consultation rates for moderate-to-severe patients in both ischemic and hemorrhagic strokes, indicating a systematic enhancement in early rehabilitation access regardless of stroke severity. Transfers to comprehensive rehabilitation increased in parallel, with a shorter time from admission to transfer and a reduced rehabilitation length of stay. The most dramatic improvements were observed in moderate-to-severe ischemic stroke, where transfer rates more than doubled (12.6% to 31.4%) and transfer times decreased by over 60% (26.5 to 10.3 days). This finding directly addresses concerns about severity-related confounding, as it demonstrates that patients with more severe deficits—who typically require more intensive rehabilitation—received proportionally greater access to comprehensive services over time. The introduction of national stroke rehabilitation guidelines in 2008,[6,30] and subsequent policy initiatives appear instrumental in these gains. The expanding role of stroke specialists, including rehabilitation physicians, has accelerated improvements in patient selection and timing, resulting in more efficient referrals and better rehabilitation outcomes across all severity levels. Most importantly, home discharge rates following rehabilitation climbed steadily from 31.6% to 43.8%, with improvements observed in both mild and moderate-to-severe ischemic stroke groups, reflecting the efficacy of a comprehensive approach.[31] However, standardized criteria for patient selection remain lacking, highlighting the need for further research to refine evidence-based guidelines and ensure the most effective use of rehabilitation resources.

This study has several limitations. The 2008 data were collected retrospectively through electronic chart review, which may result in quality differences compared to the prospectively collected cohort data from 2014 and 2020. Additionally, as our study focused on first-ever stroke patients in tertiary hospitals, excluding recurrent strokes and patients who died in the emergency room, it may not fully represent the entire stroke patient population or reflect the complete picture of stroke treatment and rehabilitation across all healthcare settings in Korea. Despite these limitations, our study provides valuable insights into the changes in acute stroke care and rehabilitation in Korea over a 12-year period. To our knowledge, this is the first comprehensive dataset demonstrating how acute stroke management has evolved in Korea from 2008 to 2020, reflecting the positive impact of systematic quality improvement initiatives and advancements in stroke care. These findings underscore the importance of sustained investment in evidence-based strategies and quality improvement in acute stroke care. Finally, our cohort comprised only first-ever strokes admitted within seven days to three tertiary university hospitals. This design excludes an estimated 20% of ischemic and 10% of hemorrhagic recurrences. In addition, admission practices have evolved over time, with very mild ischemic strokes increasingly being hospitalized for evaluation, which may have inflated the ischemic counts in the later cohorts. The lack of other Korean studies with identical inclusion criteria prevents a direct external comparison—particularly of the 2008 hemorrhagic proportion—but underscores the value of our work as a longitudinal, hospital-based epidemiologic study. Despite these limitations, our dataset provides unique insight into 12-year trends in acute stroke care and rehabilitation in South Korea and highlights the positive impact of sustained, evidence-based quality-improvement initiatives.


https://doi.org/10.3346/jkms.2026.41.e113

## SUPPLEMENTARY MATERIALS

### Supplementary Table 1

Hospital courses across three time periods

### Supplementary Table 2

Rehabilitation treatment across three time periods

## REFERENCES

1. Martin SS, Aday AW, Almarzooq ZI, Anderson CAM, Arora P, Avery CL, et al. 2024 Heart disease and stroke statistics: a report of US and global data from the American Heart Association. *Circulation* 2024;149(8):e347-913. PUBMED | CROSSREF
2. Feigin VL, Stark BA, Johnson CO, Roth GA, Bisignano C, Abady GG, et al. Global, regional, and national burden of stroke and its risk factors, 1990–2019: a systematic analysis for the Global Burden of Disease Study 2019. *Lancet Neurol* 2021;20(10):795-820. PUBMED | CROSSREF
3. Kim JY, Kang K, Kang J, Koo J, Kim DH, Kim BJ, et al. Executive summary of stroke statistics in Korea 2018: a report from the epidemiology research council of the Korean Stroke Society. *J Stroke* 2019;21(1):42-59. PUBMED | CROSSREF
4. Seo KD, Suh SH. Endovascular treatment in acute ischemic stroke: a nationwide survey in Korea. *Neurointervention* 2018;13(2):84-9. PUBMED | CROSSREF
5. Kim BJ, Park JM, Kang K, Lee SJ, Ko Y, Kim JG, et al. Case characteristics, hyperacute treatment, and outcome information from the clinical research center for stroke-fifth division registry in South Korea. *J Stroke* 2015;17(1):38-53. PUBMED | CROSSREF
6. Jung SH. Stroke Rehabilitation Fact Sheet in Korea. *Ann Rehabil Med* 2022;46(1):1-8. PUBMED | CROSSREF
7. Powers WJ, Rabinstein AA, Ackerson T, Adeoye OM, Bambakidis NC, Becker K, et al. Guidelines for the early management of patients with acute ischemic stroke: 2019 update to the 2018 guidelines for the early management of acute ischemic stroke: a guideline for healthcare professionals from the American Heart Association/American Stroke Association. *Stroke* 2019;50(12):e344-418. PUBMED | CROSSREF
8. Feigin VL, Norrving B, Mensah GA. Global burden of stroke. *Circ Res* 2017;120(3):439-48. PUBMED | CROSSREF
9. Leigh JH, Kim WS, Sohn DG, Chang WK, Paik NJ. Transitional and long-term rehabilitation care system after stroke in Korea. *Front Neurol* 2022;13:786648. PUBMED | CROSSREF
10. Chang WH, Shin YI, Lee SG, Oh GJ, Lim YS, Kim YH. Characteristics of inpatient care and rehabilitation for acute first-ever stroke patients. *Yonsei Med J* 2015;56(1):262-70. PUBMED | CROSSREF
11. Chang WH, Sohn MK, Lee J, Kim DY, Lee SG, Shin YI, et al. Korean Stroke Cohort for functioning and rehabilitation (KOSCO): study rationale and protocol of a multi-centre prospective cohort study. *BMC Neurol* 2015;15(1):42. PUBMED | CROSSREF
12. Oh MS, Yu KH, Lee JH, Jung S, Ko IS, Shin JH, et al. Validity and reliability of a Korean version of the national institutes of health stroke scale. *J Clin Neurol* 2012;8(3):177-83. PUBMED | CROSSREF
13. Glasgow Coma Scale. Do it this way. https://www.glasgowcomascale.org/download-aid/. Updated 2025. Accessed January 10, 2025.
14. Kogan E, Twyman K, Heap J, Milentijevic D, Lin JH, Alberts M. Assessing stroke severity using electronic health record data: a machine learning approach. *BMC Med Inform Decis Mak* 2020;20(1):8. PUBMED | CROSSREF
15. Kim JY, Lee KJ, Kang J, Kim BJ, Kim SE, Oh H, et al. Acute stroke care in Korea in 2013–2014: national averages and disparities. *J Korean Med Sci* 2020;35(20):e167. PUBMED | CROSSREF
16. Shin S, Kim YW, Sheen SH, Park SQ, Jin SC, Jeon JP, et al. Epidemiology and functional outcome of acute stroke patients in Korea using nationwide data. *J Korean Neurosurg Soc* 2025;68(2):159-76. PUBMED | CROSSREF
17. Kim YS, Park SS, Bae HJ, Heo JH, Kwon SU, Lee BC, et al. Public awareness of stroke in Korea: a population-based national survey. *Stroke* 2012;43(4):1146-9. PUBMED | CROSSREF
18. Oh GJ, Moon J, Lee YM, Park HK, Park KS, Yun YW, et al. Public awareness of stroke and its predicting factors in Korea: a national public telephone survey, 2012 and 2014. *J Korean Med Sci* 2016;31(11):1703-10. PUBMED | CROSSREF

19. Hong KS, Bang OY, Kim JS, Heo JH, Yu KH, Bae HJ, et al. Stroke statistics in Korea: Part II stroke awareness and acute stroke care, a report from the Korean Stroke Society and Clinical Research Center For Stroke. *J Stroke* 2013;15(2):67-77. PUBMED | CROSSREF
20. Toyoda K, Yoshimura S, Nakai M, Koga M, Sasahara Y, Sonoda K, et al. Twenty-year change in severity and outcome of ischemic and hemorrhagic strokes. *JAMA Neurol* 2022;79(1):61-9. PUBMED | CROSSREF
21. Kimura K, Minematsu K, Yamaguchi T. Characteristics of in-hospital onset ischemic stroke. *Eur Neurol* 2006;55(3):155-9. PUBMED | CROSSREF
22. O'Donnell MJ, Chin SL, Rangarajan S, Xavier D, Liu L, Zhang H, et al. Global and regional effects of potentially modifiable risk factors associated with acute stroke in 32 countries (INTERSTROKE): a case-control study. *Lancet* 2016;388(10046):761-75. PUBMED | CROSSREF
23. Lee EJ, Kim DY, Jeong HY, Lee KJ, Lee HK, Koh YH, et al. The results of a study on the management of acute ischemic stroke by establishing a nationwide cohort and registry in Korea. *Public Health Wkly Rep* 2022;15(43):2734-52.
24. Jung WS, Seo KD, Suh SH. National trends in medical costs and prognosis of acute ischemic stroke patients in endovascular thrombectomy era: analysis using medical claim data in Korea. *Neurointervention* 2022;17(3):152-60. PUBMED | CROSSREF
25. Lindgren A, Vergouwen MD, van der Schaaf I, Algra A, Wermer M, Clarke MJ, et al. Endovascular coiling versus neurosurgical clipping for people with aneurysmal subarachnoid haemorrhage. *Cochrane Database Syst Rev* 2018;8(8):CD003085. PUBMED | CROSSREF
26. Lanzino G, Murad MH, d'Urso PI, Rabinstein AA. Coil embolization versus clipping for ruptured intracranial aneurysms: a meta-analysis of prospective controlled published studies. *AJNR Am J Neuroradiol* 2013;34(9):1764-8. PUBMED | CROSSREF
27. Moon J, Seo Y, Lee HH, Lee H, Kaneko F, Shin S, et al. Incidence and case fatality of stroke in Korea, 2011–2020. *Epidemiol Health* 2024;46:e2024003. PUBMED | CROSSREF
28. Bae HJ, Yoon DS, Lee J, Kim BK, Koo JS, Kwon O, et al. In-hospital medical complications and long-term mortality after ischemic stroke. *Stroke* 2005;36(11):2441-5. PUBMED | CROSSREF
29. Park HK, Kim SE, Cho YJ, Kim JY, Oh H, Kim BJ, et al. Quality of acute stroke care in Korea (2008–2014): retrospective analysis of the nationwide and nonselective data for quality of acute stroke care. *Eur Stroke J* 2019;4(4):337-46. PUBMED | CROSSREF
30. Kim YH, Han TR, Jung HY, Chun MH, Lee J, Kim DY, et al. Clinical practice guideline for stroke rehabilitation in Korea. *Brain Neurorehabil* 2009;2(1):1-38. PUBMED | CROSSREF
31. Kim DH, Kim DY, Lee J, Sohn MK, Song MK, Shin YI, et al. Effects of intensive rehabilitation in the acute hospital in patients with severe stroke: the Korean Stroke cohort for functioning and rehabilitation study. *Jugan Geongang Gwa Jilbyeong* 2023;16(41):1371-89. PUBMED