Incidence and Costs of Secondary Stroke Events in Patients with Ischemic Stroke or Transient Ischemic Attack of Non-Cardioembolic Origin

Michael A. Head,[1] Valerie Haley,[1] Emily Durden,[2] Steven Caproni,[2] Gilbert Ko,[2,†] Vincent Willey,[1] Kaitlyn Hopkins,[1] Jean Lee,[2] Seemant Chaturvedi,[3] Lynda Lisabeth[4,5]

[1]Carelon Research, Wilmington, DE, USA; [2]Bayer HealthCare Pharmaceuticals Inc., Whippany, NJ, USA; [3]University of Maryland School of Medicine, Baltimore, MD, USA; [4]Department of Epidemiology, University of Michigan School of Public Health, Ann Arbor, MI, USA; [5]Stroke Program, University of Michigan Medical School, Ann Arbor, MI, USA
[†]Current affiliation: Johnson & Johnson Inc, Horsham, PA, USA

EE215

Copies of this e-poster obtained through QR, AR and/or text key codes are for personal use only and may not be reproduced without written permission of the authors.

Aim

- To evaluate the real-world incidence of secondary ischemic stroke (IS) and medical costs associated with secondary stroke events in patients with IS or transient ischemic attack (TIA) of non-cardioembolic ischemic (NCIS) origin.

Introduction

- In the United States, an estimated 7.8 million adults have a history of stroke, with approximately 610,000 incident (first-ever) strokes and around 185,000 (23%) secondary strokes occurring annually.[1,2]
- Following an initial stroke, the risk of secondary stroke remains high, with secondary stroke rates of 5–21% at 1 year and 16–35% at 5 years.[3,4]
- A TIA – a brief, stroke-like episode caused by a temporary interruption of cerebral blood flow – is a common precursor to IS and serves as an important warning signal for future stroke risk.[5]
- Approximately 87% of all strokes are ischemic. More than 70% of IS are NCIS, which are primarily the result of large-artery atherosclerosis or small-vessel disease.[1,6]
- NCIS contributes substantially to long-term morbidity and mortality in the United States.[1,7]
- Stroke burden extends beyond the acute event to include a substantial impact of recurrent stroke on patients and caregivers.[8]
- Recurrent IS are more likely to be fatal and disabling than the index (first) stroke.[8] In addition, recurrent IS are associated with a high-cost impact on patients and the healthcare and social system.[8]

Methods

- This retrospective cohort study identified adults with an index NCIS or TIA between January 1, 2016, and June 30, 2024, using data from the Healthcare Integrated Research Database (HIRD®),[9] based on inpatient (IP) or emergency department (ED) encounters.
- To limit the analysis to non-cardioembolic events, patients with evidence of atrial fibrillation or atrial flutter, left ventricular thrombus, mechanical heart valves, or use of oral anticoagulants during the baseline period were excluded.
- The baseline period comprised 365 days prior to the index event, excluding the index date.
- Secondary IS was defined as any subsequent IP or ED encounter with an International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM)[10] diagnosis code for IS.
- Follow-up extended from the day after the index IP or ED encounter until the end of continuous enrollment, end of the study period, or death, whichever occurred first.
- Kaplan–Meier analysis was used to show time to a composite outcome of secondary IS or all-cause death.
- Healthcare costs were inflation-adjusted to 2024 US dollars using the Medical Care Consumer Price Index.
- Stroke-related healthcare utilization in the United States was identified by ICD-10-CM codes in any diagnosis position (primary position for IP stays) indicating stroke. Stroke-related pharmacy utilization included thrombolytic or antiplatelet prescriptions.

Results

- The study included 80,864 individuals with a mean (standard deviation [SD]) age of 62.4 (13.7) years; 51.4% were male and 75.9% were non-Hispanic White.
- Over a mean (SD) follow-up of 2.3 (2.1) years, 5,715 (7.1%) experienced at least one secondary IS (**Table 1**).
  - Secondary IS was more frequent following index IS (8.1%) than TIA (3.8%).
- Patients with secondary IS had more comorbidities, including diabetes (38.9% vs 26.4%) and coronary artery disease (19.4% vs 14.4%) than those without secondary IS (**Table 1**).

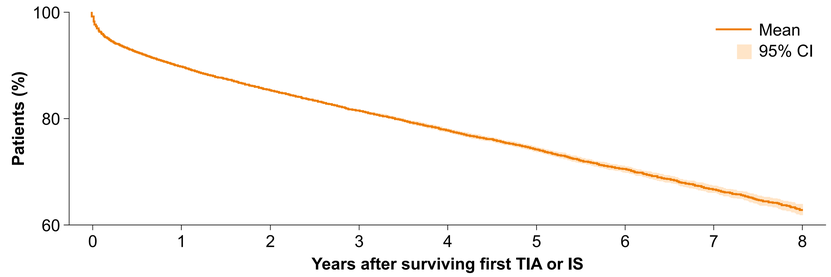
Table 1. Baseline demographics and clinical characteristics

	Total N=80,864	No secondary IS n=75,149	≥1 secondary IS n=5,715
Type of index event, n (%)			
IS	61,161 (75.6)[†]	56,202 (74.8)	4,959 (86.8)
TIA	19,703 (24.4)	18,947 (25.2)	756 (13.2)
Demographics			
Age, years, mean (SD)	62.4 (13.7)	62.3 (13.7)	64.7 (13.5)
Male, n (%)	41,535 (51.4)	38,512 (51.2)	3,023 (52.9)
White non-Hispanic, n (%)	61,361 (75.9)	57,068 (75.9)	4,293 (75.1)
US geographic region, n (%)			
Northeast	11,256 (13.9)	10,473 (13.9)	783 (13.7)
Midwest	25,414 (31.4)	23,456 (31.2)	1,958 (34.3)
South	29,773 (36.8)	27,779 (37.0)	1,994 (34.9)
West	13,991 (17.3)	13,033 (17.3)	958 (16.8)
Unknown	430 (0.5)	408 (0.5)	22 (0.4)
Urbanicity of residence, n (%)			
Urban	41,748 (51.6)	38,754 (51.6)	2,994 (52.4)
Suburban	21,153 (26.2)	19,780 (26.3)	1,373 (24.0)
Rural	16,262 (20.1)	15,002 (20.0)	1,260 (22.0)
Unknown	1,701 (2.1)	1,613 (2.1)	88 (1.5)
Payor, n (%)			
Commercial	59,627 (73.7)	55,941 (74.4)	3,686 (64.5)
Medicare Advantage	21,237 (26.3)	19,208 (25.6)	2,029 (35.5)
Quartiles of SES index[‡] score, n (%)			
Patients with available data	76,923 (95.1)	71,477 (95.1)	5,446 (95.3)
1 (lowest SES quartile [worst])	15,602 (20.3)	14,388 (20.1)	1,214 (22.3)
2	20,370 (26.5)	18,821 (26.3)	1,549 (28.4)
3	21,421 (27.8)	19,937 (27.9)	1,484 (27.2)
4 (highest SES quartile [best])	19,530 (25.4)	18,331 (25.6)	1,199 (22.0)
Length of post-index observation period			
Length of follow-up period, years, mean (SD)	2.3 (2.1)	2.3 (2.1)	3.1 (2.3)
Comorbidities, n (%)			
Chronic kidney disease	8,356 (10.3)	7,556 (10.1)	800 (14.0)
Congestive heart failure	4,232 (5.2)	3,862 (5.1)	370 (6.5)
Coronary artery disease	11,910 (14.7)	10,803 (14.4)	1,107 (19.4)
Dementia	2,411 (3.0)	2,233 (3.0)	178 (3.1)
Diabetes	22,060 (27.3)	19,837 (26.4)	2,223 (38.9)
Hyperlipidemia	39,764 (49.2)	36,643 (48.8)	3,121 (54.6)
Hypertension	47,053 (58.2)	43,184 (57.5)	3,869 (67.7)
Intracranial bleeding	379 (0.5)	342 (0.5)	37 (0.6)
Ischemic heart disease/coronary heart disease	16,537 (20.5)	15,021 (20.0)	1,516 (26.5)
Major bleeding events, excluding intracranial bleeding	7,422 (9.2)	6,853 (9.1)	569 (10.0)
Myocardial infarction	3,200 (4.0)	2,883 (3.8)	317 (5.5)
Venous thromboembolism	2,743 (3.4)	2,536 (3.4)	207 (3.6)

Baseline is 365 days prior to the start of the index event.
[†]Includes patients categorized as having IS alone and IS plus TIA
[‡]The SES index is a composite measure based on seven factors (unemployment rate, poverty rate, median household income, median home value, high school degree, college degree, persons per room). It is reported in quartiles for the national sampled population. This 5-year average is from the American Community Survey 2016–2020. Quartiles are derived from the national population.
IS, ischemic stroke; SD, standard deviation; SES, socioeconomic status; TIA, transient ischemic attack.

- Survival without secondary IS or death was 89.6% at 1 year and 77.7% at 4 years, with elevated recurrence risk both early (within 90 days) and during long-term follow-up (**Figure 1**).

Figure 1. Kaplan–Meier curve of time to first recurrent IS or death



Not censored, n	80,864	50,386	33,133	21,968	14,722	9,650	5,819	3,059	1,068
At risk, %	100	62.3	41.0	27.2	18.3	11.9	7.2	3.8	1.3
Survival probability	100	89.6	85.3	81.4	77.7	74.2	70.5	66.7	62.9

All outcomes were censored by disenrollment or end of study period.
CI, confidence interval; IS, ischemic stroke; TIA, transient ischemic attack.

- The mean (SD) total cost of the index event was $23,783 ($46,472; **Table 2**).
- The mean (SD) total cost of any secondary stroke was $26,492 ($48,632; **Table 2**).
- The mean (SD) total cost of the first secondary IS was $26,597 ($49,758; **Table 2**).
- The mean (SD) cost of second or later secondary strokes was $25,860 ($41,252; **Table 2**).

Table 2. Cost of index and secondary stroke events[†]

	Main population			
	Total	No secondary strokes	1 secondary stroke	≥2 secondary strokes[‡]
N	80,864	75,149	4,940	775
Total cost of index event, $				
Mean (SD)	23,783 (46,472)	23,702 (46,565)	25,160 (47,068)	22,956 (30,985)
Median (IQR)	11,460 (18,412)	11,343 (18,278)	13,161 (19,890)	12,331 (19,181)
Total cost of index event, IP only, $				
Mean (SD)	32,137 (54,080)	32,308 (54,514)	30,736 (51,054)	26,988 (32,812)
Median (IQR)	17,147 (24,420)	17,152 (24,528)	17,322 (23,507)	15,636 (23,439)
Total cost of index event, ED only, $				
Mean (SD)	6,067 (8,674)	6,089 (7,896)	5,764 (19,270)	4,511 (3,607)
Median (IQR)	4,148 (5,230)	4,205 (5,263)	3,240 (4,771)	3,276 (3,810)
Total cost of any secondary stroke, $				
Mean (SD)	26,492 (48,632)	–	27,268 (51,750)	24,271 (38,266)
Median (IQR)	13,025 (22,328)	–	13,052 (22,991)	13,011 (20,780)
Total cost of first secondary stroke, $				
Mean (SD)	26,597 (49,758)	–	27,268 (51,750)	22,320 (34,172)
Median (IQR)	12,858 (22,351)	–	13,052 (22,991)	12,099 (19,341)
Total cost of second or later secondary strokes, $				
Mean (SD)	25,860 (41,251)	–	–	25,860 (41,251)
Median (IQR)	13,782 (21,924)	–	–	13,782 (21,924)

[†]Costs include those having both NCIS and TIA.
[‡]Refers to second or later secondary stroke.
ED, emergency department; IP, inpatient; IQR, interquartile range; SD, standard deviation.

Conclusions

- Secondary ischemic stroke is a frequent complication following an initial IS or TIA, and patients experiencing secondary IS have a higher comorbidity burden, emphasizing the importance of early secondary prevention.
- Secondary IS events are also associated with substantial medical costs, highlighting the economic value of effective secondary preventing strategies.

References

1. Tsao CW, et al. *Circulation*. 2023;147:e93–e621.
2. Centers for Disease Control and Prevention. Cerebrovascular Disease or Stroke. Available at: https://www.cdc.gov/nchs/fastats/stroke.htm. Accessed April 22, 2026.
3. Mohan KM, et al. *Stroke*. 2011;42:1489–1494.
4. Boulanger B, et al. *J Am Heart Assoc*. 2018;7:e007267.
5. Centers for Disease Control and Prevention. About Stroke. Available at: https://www.cdc.gov/stroke/about/index.html. Accessed April 21, 2026.
6. Hoshino T, et al. *Eur Stroke J*. 2019;4:65–74.
7. Centers for Disease Control and Prevention. Stroke Facts. Available at: https://www.cdc.gov/stroke/data-research/facts-stats/index.html. Accessed April 21, 2026.
8. Caso V, et al. *Eur Stroke J*. 2026;11:aakaf012.
9. Carleon Research. Healthcare Integrated Research Database (HIRD®). Available at: https://www.carelonresearch.com/our-unique-value/healthcare-integrated-research-database. Accessed April 21, 2026.
10. Centers for Disease Control and Prevention. Classification of Diseases, Functioning, and Disability, ICD-10-CM. Available at: https://www.cdc.gov/nchs/icd/icd-10-cm/index.html. Accessed April 21, 2026.

Acknowledgements

Funding for this research was provided by Bayer U.S. LLC (Bayer), which also funded the development of the poster; the study sponsor was involved in all stages of the study research and poster preparation. Medical writing support was provided by Charlotte Simpson, PhD, and editorial support was provided by Ian Norton, PhD, of the Prime Group of Companies (Knutsford, UK); this support was funded by Bayer.

Disclosures

E.D., S.C., G.K., and J.L. are employees of Bayer. M.A.H., V.H., V.W., and K.H. are employees of Carelon Research, a company that has provided paid consulting services to Bayer. S.C. and L.L. receive research funding from the National Institutes of Health and serve as paid consultants of Bayer.

Presented at ISPOR – The Professional Society for Health Economics and Outcomes Research Annual Meeting 2026, May 17–20, 2026, Philadelphia, PA, USA.