

The Mortality After Recurrence Stroke Among The Ischemic Stroke Patients In Thailand

By

Krissana Aunthakot

Faculty of Public Health, Khon Kaen University, Thailand

Email: krissana.aunthakot@gmail.com

ORCID 0000-0001-7150-5397

Wongsa Loahasiriwong

Faculty of Public Health, Khon Kaen University, Thailand

Corresponding Author Email: drwongsa@gmail.com

ORCID 0000-0001-7838-716X

Somsak Tiamkao

Faculty of Medicine, Khon Kaen University, Thailand

Email: somtia@kku.ac.th

ORCID 0000-0001-5178-478X

Kittipong Sornlorm

Faculty of Public Health, Khon Kaen University, Thailand

Email: kittsorn@kku.ac.th

ORCID 0000-0002-2734-0764

Surachai Phimha

Faculty of Public Health, Khon Kaen University, Thailand

Email: suraphi@kku.ac.th

ORCID 0000-0003-2248-546X

Roshan Kumar Mahato

Department of Public Health and Community Program, Dhulikhel Hospital,
and Kathmandu University Hospital, Nepal

Email: mahatoroshank@kusms.edu.np

ORCID 0000-0001-9287-2743

Abstract

Introduction: Stroke is a severe disease in Thailand. It is the second leading cause of mortality after cancer. There are very few studies on the magnitude of the mortality after recurrence stroke has been conducted in Thailand. So, this study aimed to describe the magnitude of mortality among recurrence ischemic stroke patients in Thailand.

Methodology: This retrospective cohort study collected the data from the neurological disease electronic database of Thailand which has been primarily administered by the National Health Security Office (NHSO). The study period was between January 2009 and September 2020 in hospitals under the NHSO system.

Result: Over the study period, the recurrence of ischemic stroke was observed among 73,506 patients. A total of 37,189 patients demised i.e. 50.59 %. Which shows that the mortality trend decreased from 2009 to 2020. The total mortality was 50.59% (95% CI: 50.23 - 50.96)

in which hemorrhagic stroke (73.36%, 95% CI: 72.48 - 74.22) that is almost two times higher than ischemic stroke. In addition, the mortality within 30 days in total was 18.07% (95% CI: 17.79 - 18.35) and the mortality within 90 days in total was 26.21% (95% CI: 25.89 - 26.53). The age group with the highest rate of mortality was their 80s.

Conclusion: Hemorrhagic stroke has almost two times higher mortality rate as compared to ischemic stroke which has been increased by atrial fibrillation.

Key words: Second stroke, Death, Hemorrhagic stroke, Ischemic stroke, Chronic disease

Introduction

Stroke is a severe disease that affects the obstruction of blood supply to the brain, which can result in brain damage or death. The major types of stroke consist of ischemic stroke and hemorrhagic stroke, ischemic stroke is the most common type that occurs in patients, accounting for more than 80% of stroke cases. (World stroke organization, 2021). The stroke is concentrated worldwide, stroke belt in the low-and middle income and developing countries with substantial disparities in stroke disease burden among countries and regions. Although the past decade, there has been some success in reducing the age-standardized mortality and morbidity from stroke, particularly in high-income countries, the total disease burden from stroke on a global basis is still substantial, particularly in developing countries. The stroke trends in epidemiological risk factors along with aging society and population growth, and the capacity of health service systems in the next decades are expected to lead to increases in the absolute burden of disease from a stroke. (Kim, A. S., Cahill, E., & Cheng, N. T. (2015). Worldwide, stroke remains significant health problem in many countries with around 13 million new cases and more than 6 million deaths each year. This trend of stroke leads to the second cause of death and people over 100 million in the world had experienced and lived with the effects of stroke. (Virani, S. S., et al, 2021). Stroke is the second leading cause of mortality below cancer similar to the global trends which increased mortality rate by around four percent within five years (48.7 per 100,000 population in 2016 and 52.8 per 100,000 population in 2020) in Thailand (Disease Control Department of Thailand, 2019, Ministry of Public Health Thailand, 2021).

The health insurance system in Thailand is currently separated into three main programs, namely the Civil Servants System (CSS) for civil servants and their families, the Social Security System (SSS) for private employees and the National Health Security Program (NHSP) for those not eligible under the first two programs and this scheme covering Thailand population more than 70 %. Furthermore, there are still disparities in health care between the health insurance schemes. The NHSP challenge is population is going in an aging society and the disease profiles of the population structure are changing alongside the modernization of Thai people's lifestyles which is the cause of rising healthcare costs (Thailand development research institute, 2013 and Sumriddetchkajorn, K., et al., 2019). With the ongoing increased stroke trends, the number of patients vulnerable to stroke recurrence has increased substantially. The recurrence can occur as the same or another type and recurrences tend to be more severe than the initial stroke. It is also a challenge for managing the health system to tackle that problem to decrease mortality and different stroke outcomes.

However, there have been few studies on the magnitude of the mortality after recurrence stroke of patients with ischemic stroke and relevant factors remain limited, particularly in low - and middle-income countries. Therefore, this research aimed to describe the magnitude of mortality among recurrence ischemic stroke patients under the National Health Security Program in Thailand and to provide comprehensive information for policy recommendations related to mortality after the recurrence stroke of ischemic stroke.

Method

This retrospective study used the longitudinal data that was collected from the neurological disease electronic database of Thailand that was administered by the National Health Security Office (NHSO) which is the agency that oversees the health insurance fund under the National Health Security Act. The patients included in the database consist of patients with ischemic stroke who were aged 18 years or older with a principal diagnosis in the second time of stroke determined by brain CT scan covering a time period of January 2009 to September 2020 in hospitals under the NHSO system. The data management was searched to classify patients with ischemic stroke using the International Statistical Classification of Diseases and Related Health Problems -10th Revision (ICD-10) codes I63, I65 and I66. The patients with ischemic stroke were defined by brain CT scan and principal diagnosis with ICD -10 codes no. I63, I65 and I66 in the initial stroke. The stroke recurrence type of the patients has been classified according to ICD -10 codes I63, I65 and I66 for ischemic stroke, and I60, I61 and I62 for hemorrhagic stroke. Comorbidities of the patients with recurrence stroke classified by the relevant ICD-10 codes and ICD-9 CM diagnosis. The patient's mortality data of this study were linked to the Ministry of Interior's civil registration database.

Statistical analysis was performed by using descriptive statistics to analyze the baseline characteristics and other variables that presented as frequency and proportions for categorical data and mean, standard deviation, median, maximum and minimum for continuous data. The mortality estimation of recurrence stroke patients was classified by characteristics, comorbidity and reported the 95% confidence interval (95%CI) of overall mortality over a period time of the study, mortality within 30 days and mortality within 90 days separated by comorbidities and recurrence stroke types. This present study was approved by the Ethics Committee for Human Research of Khon Kaen University reference number HE651122 and data acquisition was authorized by the NHSO as part of the Epidemiology of Neurological Disease in Thailand Project conducted by the Department of Medicine in the Faculty of Medicine at Khon Kaen University.

Result

A total of 73,506 patients with ischemic stroke were included in which higher proportion of males (54.97%). The mean age of the patients was 66.52±12.02 S.D. years with a median age of 67 years (Min:18 years, Max: 104 years). A proportion of Hypertension (HT), Diabetes Mellitus (DM) and Hyperlipidemia (HLD) patients were 54.05% 15.80% and 39.41%, respectively. The minority of the patients were having Atrial Fibrillation (AF),

Chronic Kidney Disease (CKD) and Ischemic Heart Disease (IHD). Most of them was Ischemic stroke at 86.33 % (Table 1).

Table 1. *Characteristics of the Patients with Ischemic Stroke. (n=73,506)*

Characteristics	Number	Percentage
Gender		
Male	40,405	54.97
Female	33,101	45.03
Age group(year)		
<45	3,430	4.67
45- 59	17,446	23.73
60 - 69	21,885	29.77
70 - 79	20,611	28.04
≥80	10,134	13.79
Mean 66.52: S.D. ±12.02		
Median 67, Min 18: Max 104		
Hypertension (HT)		
Yes	39,732	54.05
No	33,774	45.95
Diabetes mellitus (DM)		
Yes	11,616	15.80
No	61,890	84.20

Table 1. *Characteristics of the Patients with Ischemic Stroke. (n=73,506) cont.*

Characteristics	Number	Percentage
Hyperlipidemia (HLD)		
Yes	28,966	39.41
No	44,540	60.59
Atrial fibrillation (AF)		
Yes	7,212	9.81
No	66,294	90.19
Chronic Kidney Disease (CKD)		
Yes	4,716	6.42
No	68,790	93.58
Ischemic Heart Disease (IHD)		
Yes	3,102	4.22
No	70,404	95.78
Recurrence types of stroke		
Ischemic stroke	63,461	86.33
Hemorrhagic stroke	10,045	13.67

The mortality after recurrence stroke among ischemic stroke patients classified by years at recurrence stroke. Over the study period, the recurrence of ischemic stroke was diagnosed among 73,506 patients from 2009 to 2020. The status of death at the end of the study was 37,189 (50.59 %). The mortality trend decreased from 2009 to 2020. When considering the mortality of patients classified by year at recurrence stroke was highest in 2010 with 79.27 %

followed by patients in 2009 with 77.63 % and the lowest in 2020 i.e. 23.78 % which depends on the time of follow-up because patients included in the early period of the study had a length of follow-up than the end of the study time period (table 2).

Table 2. *The mortality after recurrence stroke among ischemic stroke patients classified by years at recurrence stroke.*

Years at recurrence stroke	Total number of patients	Total mortality	
		Number	%
2009	1,256	975	77.63
2010	2,388	1,893	79.27
2011	3,465	2,630	75.90
2012	4,200	3,572	73.21
2013	5,142	3,572	69.47
2014	5,865	3,751	63.96
2015	6,912	4,102	59.35
2016	7,694	4,133	53.72
2017	8,711	4,081	46.85
2018	9,639	3,861	40.06
2019	10,913	3,375	30.93
2020	7,321	1,741	23.78
Overall	73,506	37,189	50.59

The total mortality was 50.59% (95% CI: 50.23 - 50.96) (Table 3). The mortality was slightly higher in female (51.32%, 95% CI: 50.78 - 51.86). The age group with the highest rate of mortality was the 80s (67.53%, 95% CI: 66.61 - 68.44). The increased mortality was found in those with HT (51.80%, 95% CI: 51.31 - 52.29), DM (55.60%, 95% CI: 54.70 - 56.51), AF (69.31%, 95% CI: 68.24 - 70.38), CKD (68.64%, 95% CI: 67.29 - 69.96), and IHD (60.92%, 95% CI: 59.18 - 62.65) respectively. Interestingly, mortality is less common in patients with HLD (52.73%, 95% CI: 52.27 - 53.20). The hemorrhagic stroke (73.36%, 95% CI: 72.48 - 74.22) is almost two times higher than ischemic stroke.

The mortality within 30 days in total was 18.07% (95% CI: 17.79 - 18.35). The prevalence of mortality in females was slightly higher than males (19.14%, 95% CI: 18.72 - 19.57). The age group with the highest rate of mortality was the 80s (22.21%, 95% CI: 21.41 - 23.03). Interestingly, the increased mortality was found in those with HT (18.30%, 95% CI: 17.92 - 18.68), DM (18.29%, 95% CI: 17.59 - 19.00), AF (31.02%, 95% CI: 29.95 - 32.09), CKD (24.93%, 95% CI: 23.71 - 26.20) and IHD (21.53%, 95% CI: 20.10 - 23.02). Similarly, mortality is less common in patients with HLD (19.29%, 95% CI: 18.93 - 19.66). The hemorrhagic stroke (48.66%, 95% CI: 47.67 - 49.64) is almost four times higher than ischemic stroke.

Table 3. Prevalence of the mortality after recurrence stroke among ischemic stroke patients classified by factors.

Factors	Total number	Mortality within 30 days		Mortality within 90 days		Total mortality	
		%	95%CI	%	95%CI	%	95%CI
Overall	73,506	18.07	17.79 - 18.35	26.21	25.89 - 26.53	50.59	50.23 - 50.96
Gender							
Male	40,405	17.20	16.83 - 17.57	25.10	24.67 - 25.52	50.00	49.51 - 50.49
Female	33,101	19.14	18.72 - 19.57	27.55	27.08 - 28.04	51.32	50.78 - 51.86
Age (year)							
<45	3,430	16.03	14.82 - 17.31	22.24	20.86 - 23.67	30.35	28.81 - 31.92
45 - 59	17,446	15.75	15.21 - 16.30	22.68	22.06 - 23.31	38.45	37.72 - 39.18
60 - 69	21,885	16.72	16.23 - 17.22	24.63	24.06 - 25.20	47.42	46.75 - 48.08
70 - 79	20,611	19.78	19.23 - 20.33	28.88	28.25 - 29.50	59.28	58.61 - 59.95
≥80	10,134	22.21	21.41 - 23.03	31.59	30.68 - 32.50	67.53	66.61 - 68.44
Hypertension (HT)							
Yes	39,732	18.30	17.92 - 18.68	26.47	26.04 - 26.91	51.80	51.31 - 52.29
No	33,774	17.81	17.41 - 18.22	25.89	25.43 - 26.36	49.17	48.64 - 49.71
Diabetes mellitus (DM)							
Yes	11,616	18.29	17.59 - 19.00	27.79	26.97 - 28.61	55.60	54.70 - 56.51
No	61,890	18.03	17.73 - 18.33	25.91	25.56 - 26.26	49.65	49.26 - 50.04
Hyperlipidemia (HLD)							
Yes	28,966	16.19	15.78 - 16.62	23.81	23.32 - 24.30	47.29	46.72 - 47.87
No	44,540	19.29	18.93 - 19.66	27.77	27.35 - 28.18	52.73	52.27 - 53.20
Atrial fibrillation (AF)							
Yes	7,212	31.02	29.95 - 32.09	42.02	40.88 - 43.18	69.31	68.24 - 70.38
No	66,294	16.67	16.38 - 16.95	24.48	24.16 - 24.81	48.56	48.17 - 48.93
Chronic kidney disease (CKD)							
Yes	4,716	24.93	23.71 - 26.20	36.67	35.28 - 38.06	68.64	67.29 - 69.96
No	68,790	17.60	17.32 - 17.89	25.49	25.16 - 25.81	49.35	48.98 - 49.73
Ischemic heart disease (IHD)							
Yes	3,102	21.53	20.10 - 23.02	30.95	29.32 - 32.61	60.92	59.18 - 62.65
No	70,404	17.92	17.63 - 18.21	26.00	25.67 - 26.32	50.14	49.77 - 50.51
Recurrence stroke types							
Ischemic	63,461	13.23	12.97 - 13.50	21.41	21.10 - 21.73	46.99	46.60 - 47.38
Hemorrhagic	10,045	48.66	47.67 - 49.64	56.48	55.51 - 57.45	73.36	72.48 - 74.22

Note: % = % of mortality, 95%CI = 95% confidence interval

The mortality within 90 days in total was 26.21% (95% CI: 25.89 - 26.53). The prevalence of mortality in female was slightly higher than males (27.55%, 95% CI: 27.08 - 28.04). The age group with the highest rate of mortality was the 80s (31.59%, 95% CI: 30.68 - 32.50). The increased mortality was found in those with HT (26.47%, 95% CI: 26.04 - 26.91), DM (27.79%, 95% CI: 26.97 - 28.61), AF (42.02%, 95% CI: 40.88 - 43.18), CKD (36.67%, 95% CI: 35.28 - 38.06) and IHD (30.95%, 95% CI: 29.32 - 32.61). In addition, mortality is less

common in patients with HLD (27.77%, 95% CI: 27.35 - 28.18). The hemorrhagic stroke (56.48%, 95% CI: 55.51 - 57.45) is almost three times higher than ischemic stroke.

Discussion

Over the total follow-up time of 11 years and 9 months found the total mortality of patients with recurrence stroke was 50.59% (95% CI: 50.23 - 50.96). When considering in short term within 30 days found the mortality was 18.07% (95% CI: 17.79 - 18.35). It is difficult to compare the results of this study with other studies because only a few recurrence stroke patients were studied. However, the mortality of this study was higher around three times than the first stroke in Germany by Stahmeyer, J. T. et al. (2019) and also higher than the previous study in Asia by Zhang, R., et al. (2020). However, this outcome was lower than the previous study in Sub-Saharan Africa by Adoukonou, T., et al. (2021). The mortality within 90 days in total was 26.21% (95% CI: 25.89 - 26.53), the result classified each factor similarly to the overall.

Considering the mortality classified by factors was found slightly higher in female (51.32%, 95% CI: 50.78 - 51.86) than male (50.00%, 95% CI: 49.51 - 50.49) because of the differences in physical and hormonal may be effective to the different outcome (Carcel, C., et al., 2020 and Bushnell, C. D., et al., 2018) and the result similar with the study among stroke inpatients in Thailand by Kongbunkiat, K., et al., (2015). It is well known that stroke is more common in elderly people and lead to death and this study found elderly patients with recurrence stroke were more likely to cause death than the younger group similar to previous in Lithuania by Radisauskas, R., et al (2019) and the study by Yan, F., et al. (2018) that researched five years follow-up in China. Hypertension is an important factor that has been found to lead to increased mortality because very high blood pressure increases the risk of rupture of the blood vessels in the brain, it causes mortality of patients which is consistent with the previous studies in 92 countries by Lin, Q., et al, (2022) and the study by Lackland, D. T., et al (2014) found controlling blood pressure as the lower for patients can reduced mortality among patients with stroke. The mortality of patients with DM, Interestingly, there was little difference in the 30-day loss of death among patients with DM and without DM. However, overall at the end of the study found mortality among patients with DM was greater which consistent with the previous study in the United Kingdom by Di Angelantonio, E., et al, (2015) and the result similar to a meta-analysis by Lau, L. H., et al. (2019) that found acute hyperglycemia and diabetes were associated with poorer outcomes after initial stroke: including higher mortality and poorer neurological and functional outcomes. The mortality is less common in patients with HLD (19.29%, 95% CI: 18.93 - 19.66) because it might be caused by the HLD medicine that the patient received, resulting increase blood flow. This result is similar with the study in Taiwan (Yin, J. H., et al., 2021) and study in United State (Yeramaneni, S., et al., 2018).

The AF patient has greater chances of mortality of recurrence stroke (69.31%, 95% CI: 68.24 - 70.38) because AF is a symptom that shows the severity of a chronic disease especially heart disease. This result is similar with the study in United Kingdom (Flach, C., et al., 2020) and study in United State (Alkhouli, M., et al., 2018). The CKD increased mortality of recurrence stroke (68.64%, 95% CI: 67.29 - 69.96 respectively) because CKD is a disease has a high risk of death which relate to other poor status of non-communicable diseases. This result is similar with the study in Singapore (Pande, S. D., et al., 2021) and study in United State (Wetmore, J. B., et al., 2020). Hemorrhagic stroke is almost two times higher mortality rate than ischemic stroke (73.36%, 95% CI: 72.48 - 74.22) because hemorrhagic stroke causes

leakage of blood to be more complicated and difficult to treat than ischemic stroke. This result is also similar with the study in China (Tu, W. J., et al., 2021 and Yan, F., et al., 2018).

Conclusion

The mortality trend decreased from 2009 to 2020. Hemorrhagic stroke has almost two times higher mortality rate than ischemic stroke. The patient who has been diagnosed with either AF, HT, DM, or IHD increased mortality rate. HLD patients have less likely to have mortality rate. The mortality rate is increasing among aging patient specially 80s group. Therefore, there should be a plan to deal with diseases that occur in the elderly.

References

- World stroke organization (2021) Learn about stroke. Retrieved December 4, 2021. <https://www.world-stroke.org/world-stroke-day-campaign/why-stroke-matters/learn-about-stroke>
- Kim, A. S., Cahill, E., & Cheng, N. T. (2015). Global stroke belt: geographic variation in stroke burden worldwide. *Stroke*, 46(12), 3564-3570.
- Virani, S. S., Alonso, A., Aparicio, H. J., Benjamin, E. J., Bittencourt, M. S., Callaway, C. W., ... & American Heart Association Council on Epidemiology and Prevention Statistics Committee and Stroke Statistics Subcommittee. (2021). Heart disease and stroke statistics—2021 update: a report from the American Heart Association. *Circulation*, 143(8), e254-e743.
- Disease Control Department of Thailand (2019). campaigning for World Palsy Day in 2019 to raise awareness of the warning signs of a stroke and reduce the risk of paralysis. Retrieved December 2, 2021. <https://ddc.moph.go.th/dir/news.php?news=10024&deptcode=>
- Thailand Ministry of Public Health 2021, Public Health Statistics 2020, Strategic and Planning Division, Ministry of Public Health: Nonthaburi
- Thailand development research institute, (2013). Development of a pastoral approach to the health insurance system. Research Office for Health Security Development, Thai Group, Health Systems Research Institute.
- Sumriddetchkajorn, K., Shimazaki, K., Ono, T., Kusaba, T., Sato, K., & Kobayashi, N. (2019). Universal health coverage and primary care, Thailand. *Bulletin of the World Health Organization*, 97(6), 415.
- Stahmeyer, J. T., Stubenrauch, S., Geyer, S., Weissenborn, K., & Eberhard, S. (2019). The frequency and timing of recurrent stroke: an analysis of routine health insurance data. *Deutsches Ärzteblatt International*, 116(42), 711
- Zhang, R., Wang, Y., Fang, J., Yu, M., Wang, Y., & Liu, G. (2020). Worldwide 1-month case fatality of ischaemic stroke and the temporal trend. *Stroke and vascular neurology*, 5(4).
- Adoukonou, T., Kossi, O., Fotso Mefo, P., Agbetou, M., Magne, J., Gbaguidi, G., ... & Lacroix, P. (2021). Stroke case fatality in sub-Saharan Africa: systematic review and meta-analysis. *International Journal of Stroke*, 16(8), 902-916.
- Carcel, C., Woodward, M., Wang, X., Bushnell, C., & Sandset, E. C. (2020). Sex matters in stroke: a review of recent evidence on the differences between women and men. *Frontiers in Neuroendocrinology*, 59, 100870.
- Bushnell, C. D., Chaturvedi, S., Gage, K. R., Herson, P. S., Hurn, P. D., Jiménez, M. C., ... & Rundek, T. (2018). Sex differences in stroke: challenges and opportunities. *Journal of Cerebral Blood Flow & Metabolism*, 38(12), 2179-2191.

- Kongbunkiat, K., Kasemsap, N., Travanichakul, S., Thepsuthammarat, K., Tiamkao, S., & Sawanyawisuth, K. (2015). Hospital mortality from atrial fibrillation associated with ischemic stroke: a national data report. *International Journal of Neuroscience*, 125(12), 924-928.
- Radisauskas, R., Tamosiunas, A., Kranciukaite-Butylkiniene, D., Milinaviciene, E., Malinauskiene, V., Bernotiene, G., ... & RastenYTE, D. (2019). Long-term survival after stroke in Lithuania: Data from Kaunas population-based stroke registry. *Plos one*, 14(7), e0219392.
- Yan, F., Yi, Z., Hua, Y., Shen, Y., Li, M., Ding, Y., ... & Yue, W. (2018). Predictors of mortality and recurrent stroke within five years of intracerebral hemorrhage. *Neurological research*, 40(6), 466-472.
- Lin, Q., Ye, T., Ye, P., Borghi, C., Cro, S., Damasceno, A., ... & Poulter, N. R. (2022). Hypertension in stroke survivors and associations with national premature stroke mortality: data for 2· 5 million participants from multinational screening campaigns. *The Lancet Global Health*, 10(8), e1141-e1149.
- Lackland, D. T., Roccella, E. J., Deutsch, A. F., Fornage, M., George, M. G., Howard, G., ... & Towfighi, A. (2014). Factors influencing the decline in stroke mortality: a statement from the American Heart Association/American Stroke Association. *Stroke*, 45(1), 315-353.
- Di Angelantonio, E., Kaptoge, S., Wormser, D., Willeit, P., Butterworth, A. S., Bansal, N., ... & Emerging Risk Factors Collaboration. (2015). Association of cardiometabolic multimorbidity with mortality. *Jama*, 314(1), 52-60.
- Lau, L. H., Lew, J., Borschmann, K., Thijs, V., & Ekinici, E. I. (2019). Prevalence of diabetes and its effects on stroke outcomes: A meta-analysis and literature review. *Journal of diabetes investigation*, 10(3), 780-792.
- Yin, J. H., Peng, G. S., Chang, Y. T., Chu, C. M., Chien, W. C., Kao, L. T., ... & Yang, C. W. (2021). Long-Term Use of Statins Lowering the Risk of Rehospitalization Caused by Ischemic Stroke Among Middle-Aged Hyperlipidemic Patients: A Population-Based Study. *Frontiers in pharmacology*, 2661.
- Yeramaneni, S., Kleindorfer, D. O., Sucharew, H., Alwell, K., Moomaw, C. J., Flaherty, M. L., ... & Khoury, J. C. (2017). Hyperlipidemia is associated with lower risk of poststroke mortality independent of statin use: a population-based study. *International Journal of Stroke*, 12(2), 152-160.
- Flach, C., Muret, W., Wolfe, C. D., Bhalla, A., & Douiri, A. (2020). Risk and secondary prevention of stroke recurrence: a population-base cohort study. *Stroke*, 51(8), 2435-2444.
- Alkhouli, M., Alqahtani, F., Aljohani, S., Alvi, M., & Holmes, D. R. (2018). Burden of atrial fibrillation-associated ischemic stroke in the United States. *JACC: Clinical Electrophysiology*, 4(5), 618-625.
- Pande, S. D., & Morris, J. (2021). Influence of chronic kidney disease and haemodialysis on stroke outcome. *Singapore medical journal*, 62(11), 594.
- Wetmore, J. B., Herzog, C. A., Sexter, A., Gilbertson, D. T., Liu, J., & Kasner, S. E. (2020). Outcomes following ischemic stroke in older patients with CKD stages 4 and 5: A retrospective cohort study. *American Journal of Kidney Diseases*, 76(6), 784-793.
- Tu, W. J., Chao, B. H., Ma, L., Yan, F., Cao, L., Qiu, H., ... & Wang, L. D. (2021). Case-fatality, disability and recurrence rates after first-ever stroke: A study from bigdata observatory platform for stroke of China. *Brain Research Bulletin*, 175, 130-135.
- Yan, F., Yi, Z., Hua, Y., Shen, Y., Li, M., Ding, Y., ... & Yue, W. (2018). Predictors of mortality and recurrent stroke within five years of intracerebral hemorrhage. *Neurological research*, 40(6), 466-472.