



SLEEP DEPRIVATION AND THE RISK OF STROKE: A SYSTEMATIC REVIEW

¹ Arninta Rahma Khoirunnisa, ² Widya Dimar Sari

¹ Naura Medika Primary Health Clinic, Indonesia

² East Lombok Regional General Hospital, Indonesia

Corresponding Email : arninta.rahma@gmail.com

Article History :

Received date : 2026/06/21

Revised date : 2026/07/07

Accepted date : 2026/08/24

Published date : 2026/09/16



Copyright: © 2024 by the authors. Submitted for possible open access publication under the terms and conditions of the Creative Commons Attribution (BY NC) license (<https://creativecommons.org/licenses/by-nc/4.0/>).

E-ISSN :

ISSN 3048-1368



P-ISSN

ISSN 3048-1376



ABSTRACT

Background: Stroke is the second and third leading cause of death and disability worldwide, respectively, with a rapidly rising burden in low and middle income countries. Sleep disturbance, whether inadequate sleep duration, poor sleep quality, insomnia, or obstructive sleep apnea (OSA), has been extensively studied as a potentially modifiable risk factor for stroke. This review summarizes current epidemiological and mechanistic evidence on the relationship between insufficient sleep and stroke risk.

Method: A systematic literature search was conducted across PubMed/MEDLINE, Science Direct, Frontiers, Nature, PMC, and Cochrane Library, using combinations of the terms “sleep duration”, “sleep deprivation”, “insomnia”, “obstructive sleep apnea”, and “stroke risk”, formalized into Boolean strategy reported in the Method section. Eligible studies comprised meta-analysis and systematic reviews of prospective cohort studies, and randomization studies.

Results: Both short (≤ 5 -6 h/day) and long (> 8 -9 h/day) sleep duration were consistently associated with increased stroke risk in prospective cohort studies, with the lowest risk at approximately 7-7,5 h/night. Poor sleep quality, insomnia, and OSA were each independently associated with increased stroke risk, with OSA showing the strongest and most mechanistically consistent effect. However, randomization studies have not consistently demonstrated a causal relationship between sleep duration and stroke risk.

Conclusion: Available evidence supports inadequate sleep in duration and quality as a risk marker, and plausibly a modifiable risk factor, for stroke, although definitive causality still requires confirmation through intervention and genetic studies. Screening for sleep disorders, particularly OSA and chronic insomnia, was considered as a part of primary and secondary stroke prevention strategies.

Keywords: sleep duration, sleep deprivation, insomnia, obstructive sleep apnea, stroke

INTRODUCTION

Stroke remains one of the most impactful global public health problems. According to the Global Burden of Disease (GBD) Study 2021, there were 93.8 million stroke survivors, 11.9 million new stroke events, and 7.3 million stroke-related deaths worldwide in 2021, making stroke the third leading cause of death after ischemic heart disease and COVID-19. This burden is unevenly distributed and low and middle income countries account for more than 80% of new stroke events and more than 87% of stroke deaths worldwide, with rising incidence trends particularly in Southeast Asia, East Asia, and Oceania since 2015.¹

A number of risk factors have been identified for stroke, including hypertension, hypercholesterolemia, smoking, obesity, dyslipidemia, a prior history of stroke or transient ischemic attack, advanced age, diabetes mellitus, and atrial fibrillation. Among the well-established stroke risk factors, sleep disturbance has increasingly drawn attention as a potentially modifiable risk factor that is often overlooked in routine clinical practice. Sleep duration, defined as the total amount of time spent sleeping within a 24-hour period, is an important component of overall health. The generally recommended healthy sleep duration range is approximately 7-8 hours per night. Sleep disturbance spans a broad spectrum, from sleep duration that is too short or too long, to poor subjective sleep quality, chronic insomnia, and obstructive sleep apnea (OSA), which is characterized by recurrent episodes of upper-airway obstruction during sleep.²⁻⁴

Epidemiologically, the relationship between sleep duration and cardiovascular risk, including stroke, has been extensively studied through large prospective cohort studies and dose-response meta-analysis. Numerous clinical studies suggest that both excessively long and short sleep durations are associated with an increased risk of stroke. The role of sleep in stroke is complex, encompassing direct physiological impacts on the brain and indirect effects mediated through other systemic health conditions.²⁻⁴

This review was undertaken to summarize the current evidence on the relationship between inadequate sleep, in duration, quality, insomnia, and OSA and stroke risk, including the underlying pathophysiological mechanism.

METHODS

This systematic review was conducted accordance 2020 Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement. PRISMA 2020 checklist was applied throughout.⁵

Study were included based on the following criteria:

Population (P): adults (≥ 18 years) without a prior history of stroke

Intervention (I): sleep deprivation and/or poor sleep quality, assessed subjectively or objectively

Comparison (C): normal/adequate sleep duration or good sleep quality

Outcomes (O): incidence of stroke.

Study type (S): prospective or retrospective cohort studies, case control studies, cross sectional studies

Study were exclude if they: (1) Studies on sleep disorders as a primary diagnosis without a distinguishable sleep duration or quality exposure; (2) Stroke is not a distinct outcome (3) Conference abstract, editorials, letters, commentaries, and narrative reviews without original data (4) full text unavailable.

The targeted search was conducted across PubMed/MEDLINE, Science Direct, Frontiers, Nature Portfolio, PMC, and the Cochrane Library. The original search used combinations of the free-text terms “sleep duration”, “short sleep”, “long sleep”, “sleep deprivation”, “sleep quality”, “insomnia”, obstructive sleep apnea”, and “stroke risk” or “cerebrovascular disease”. We use the following Boolean: “sleep duration” OR “short sleep” OR “long sleep” OR “sleep deprivation” OR “sleep quality” OR “insomnia” OR “obstructive sleep apnea” OR “sleep apnea” AND “stroke” OR “cerebrovascular disease” OR “cerebrovascular accident” OR “stroke risk”.

Eligibility study types comprised of prospective cohort studies, large population-based cohort studies, and randomization studies evaluating the association between sleep parameters and incident stroke or stroke mortality in adult population. This review has undergone screening by two independent reviews, has produced a PRISMA flow diagram.

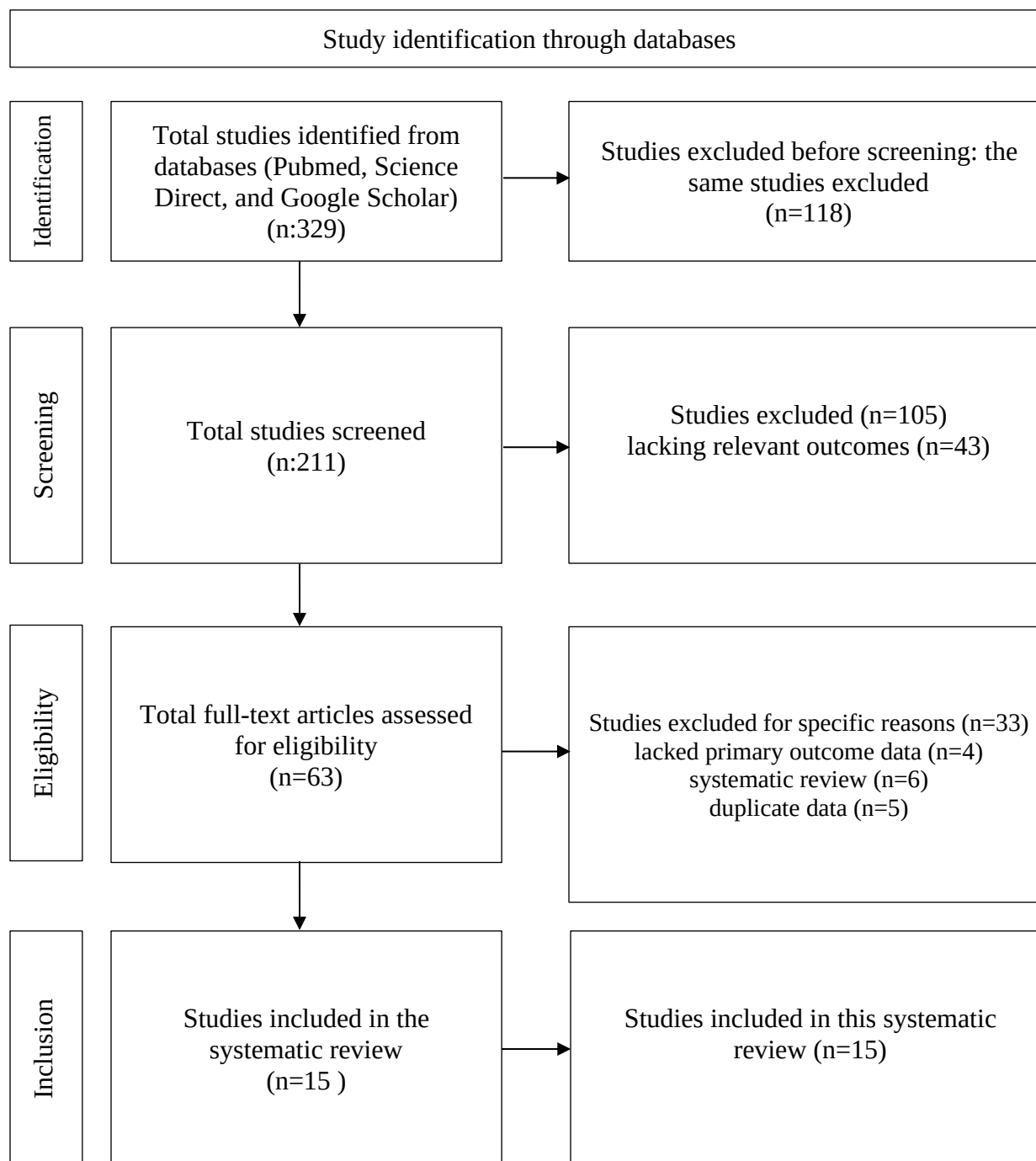


Figure 1. PRISMA diagram

RESULTS AND DISCUSSION

Table 1 summarizes the characteristics of the 15 primary empirical studies underlying this review. Systematic reviews, meta-analyses, and purely narrative mechanistic reviews are excluded from this table.

Table 1. Characteristic of Included Studies

No	Author, Year	Study Design	Population/ Sample	Exposure	Outcome	Key Findings
1.	Qureshi ,et al. 1997 ⁶	Prospective cohort	7.844 adults	Habitual sleep duration & daytime napping	incident stroke and CHD	Short and long sleep duration each associated with increased stroke risk after adjustment for conventional CV risk factor
2.	Leppävuori A, et al. 2002 ⁷	Clinical cohort	277 patients, 3-4 months post ischemic stroke	Post-stroke insomnia	Prevalence of insomnia complaint/diagnosis	56.7% reported insomnia complaint; 37.5% met DSM-IV criteria; 18.1% new

						onset after stroke
3.	Yaggi HK, et al. 2005 ⁸	Observational cohort	1,022 patients	OSA syndrome	Stroke or death	Combined HR for stroke/death 2.24 (95% CI 1.30-3.86), independent of hypertension
4.	Chen JC, et al. 2008 ⁹	Prospective cohort	Postmenopausal women	Self reported sleep duration	Ischemic stroke	Both short and long sleep duration associated with increased ischemic stroke risk, independent of CV risk factors
5.	Redline S, et al. 2010. ¹⁰	Prospective cohort	5,422 adults	OSA severity	Incident ischemic stroke	Moderate-severe OSA in men: HR 2.9 (95% CI 1.1-7.4); graded

						association across AHI quartiles
6.	Ruiter Petrov ME, et al. 2014 ¹¹	Prospective cohort	US biracial cohort	Self reported sleep duration	Incident stroke symptoms	Association nuanced by body mass and race, highlighting population-specific heterogeneity
7.	Wu MP, et al. 2014 ¹²	Nationwide cohort	Insomnia vs non insomnia patient	Insomnia subtype	Incident stroke	Insomnia associated with increased stroke risk, most pronounced in younger adults and persistent insomnia
8.	Song Q, et al. 2016 ¹³	Prospective cohort	Occupational cohort	sleep duration	Ischemic and hemorrhagic stroke	Long sleep duration associated with increased risk

						of both ischemic and hemorrhagic stroke
9.	Kawachi T, et al. 2016. ¹⁴	Prospective cohort	27,896 adults	Sleep duration	Stroke mortality	Sleep ≥ 9 h: HR 1.51 (1.16-1.97) total stroke mortality; short sleep linked to reduced hemorrhagic stroke mortality in men
10.	Jiang J, et al. 2017 ¹⁵	Experimental	Middle aged <i>Sprague dawley</i> rats	5-day REM sleep deprivation	Blood pressure and endothelial function	REM sleep deprivation increased blood pressure and reduced NO/cGMP via the eNOS pathway; reversed by L-arginine

						supplementati on
11.	Ji A, et al. 2020 ¹⁶	Prospective cohort	41.786 adults	Sleep duration (h/day), sleep quality (PSQI)	Incident stroke	Sleep <6h: RR 1.63 (95% CI 1.23-2.11); short sleep + poor quality interaction: OR 6.75% (95% CI 2.45- 14.12)
12.	Zhou L, et al. 2020 ¹⁷	Prospective cohort	31.750 adults	Sleep duration, midday napping, sleep quality	Incident stroke	Long sleep ≥ 9 h: HR 1.23 (95% CI 1.07–1.41) for total stroke; poor sleep quality: 29% – 56% higher risk across stroke subtypes. Short sleep (<6 h) was NOT significantly associated

						with total stroke risk in this cohort.
13.	Titova OE, et al. 2020 ¹⁸	Prospective cohort	79.881	Sleep duration	Incident stroke	Long sleep: HR 1.12 (1.03-1.22) total stroke; short sleep: HR 1.21 (1.03 – 1.41) intracerebral hemorrhage; MR did not support causality
14.	Zhao B, et al. 2021 ¹⁹	Prospective cohort	4.204 adults	Objectively measured sleep (in home PSG, WASO, sleep efficiency, duration)	Ischemic stroke	Highest WASO quartile: HR 3.77 (95% CI 1.81 – 7.88) vs lowest; poor sleep efficiency and short sleep also associated with higher

						incidence
15.	Hoepel SJW, et al. 2024 ²⁰	Prospective cohort	1.718 adults	Actigraph y- estimated sleep and 24-h activity rhythm	Incident stroke	No clear association for sleep duration itself; fragmented rest-activity thym: HR 1.28 per SD 95% CI 1.07- 1.53) for stroke

Short Sleep Duration and Stroke Risk

Several independent prospective cohort studies have examined the association between short sleep duration and stroke risk using primary. In one of the earliest such studies, Qureshi et al, using 10-year follow up data from 7.844 adults in the NHANES I Epidemiologic Follow-up study, found that habitual short sleep duration was associated with increased stroke risk after adjustment for conventional cardiovascular risk factors. The risk for stroke was increased in persons who reported sleeping greater than 8 hours at night compared with persons who slept between 6 and 8 hours. Daytime somnolence was also associated with stroke incidence. Persons who reported both greater than 8 hours of sleep and daytime comnolence were at the greatest risk for stroke.⁶

In a Chinese population, an 8-year prospective cohort study by Ji et al, involving 41.786 adults found a 1.63 fold higher stroke risk (95% CI 1.23-2.11) among individuals sleeping less than 6 hours per day compared with those sleeping 6-8 hours per day.¹⁶

Using objectively measures sleep via in home polysomnography in a study from Zhao et al. This study found that short sleep duration, together with poor sleep efficiency and prolonged wake

after sleep onset, was associated with a higher incidence of ischemic stroke over a mean 11-year follow up in 4,204 participants.¹⁹

Zhou et al found that short sleep (<6 hours/night) was not significantly associated with total stroke risk in that particular population, while a study using actigraphy in the population-based Rotterdam study likewise found no clear association between objectively measured sleep duration and stroke risk, although a more fragmented 24 hour rest activity rhythm was independently associated with higher stroke risk (HR 1.28 per SD increase, 95% CI 1.07 – 1.52).¹⁷

Long Sleep Duration and the U/J Shaped Relationship

Long sleep duration has also been independently associated with stroke risk in several primary cohort studies. Song et al found that long sleep duration was associated with increased risk of both ischemic and hemorrhagic stroke. Kawachi et al found that sleep duration ≥ 9 hours was associated with reduced hemorrhagic stroke mortality in men, underscoring possible mechanistic differences between stroke subtypes.^{13,14}

Chen et al found that both short and long self-reported sleep duration were associated with increased risk of ischemic stroke among post menopausal women, independent of conventional cardiovascular risk factors.⁹

Sleep Quality and Stroke Risk

Beyond duration, subjective, and objective sleep quality also appear to play an independent role in stroke risk. Ji et al in their cohort study, using the Pittsburgh Sleep Quality Index (PSQI), found an additive interaction effect between poor sleep quality and non-ideal sleep duration. Stroke risk was up to 6.75 fold higher (95% CI 2.45-14.12) in individuals with the combination of poor sleep quality and short sleep duration compared with individuals with good-quality sleep and normal duration.¹⁶

Objective measures point in a similar direction. Zhao et al, found that poor sleep efficiency and prolonged wake after sleep onset on polysomnography were independently associated with incident ischemic stroke, with the highest quartile of wake after sleep onset showing nearly a four fold increase in risk (HR 3.77, 95% CI 1.81-7.88) relative to the lowest quartile. Hoepel et al, similarly found that although actigraphy estimated sleep duration itself was not clearly associated

with stroke risk, a more fragmented and less stable 24 hour activity rhythm was independently associated with higher stroke and ischemic stroke risk.¹⁹

These findings suggest that clinical assessment of sleep-related stroke risk should not focus on hours slept, but should also account for sleep continuity and quality, whether assessed subjectively or objectively.

Insomnia and Stroke Risk

Chronic insomnia has been studied as a stroke risk factor in large administrative and clinical cohorts. Wu et al followed a nationally representative sample of insomnia and non-insomnia patients and found that insomnia was associated with an increased subsequent risk of stroke, an association that was especially pronounced among younger adults and among those with persistent, rather than remitting insomnia.¹²

The relationship between insomnia and stroke also appears to be bidirectional. In a clinical cohort of 277 patients evaluated 3-4 months after ischemic stroke, Leppävuori et al. found that 56.7% reported an insomnia complaint and 37.5% met DSM-IV criteria for insomnia; in 38.6% of cases the complaint had been present before the stroke, while in 18.1% it emerged as a new consequence of the stroke itself. This primary clinical study indicates that sleep disturbance in stroke should be viewed as a mutually reinforcing, bidirectional relationship rather than a one way risk factor alone.⁷

Obstructive Sleep Apnea (OSA) and Stroke Risk

Among all sleep disorders, OSA has the strongest and most consistent evidence of association with stroke risk from primary cohort data. The classic observational cohort by Yaggi et al, showed that OSA syndrome was independently associated with the composite outcome of stroke or death from any cause after adjustment for other risk factors including hypertension, in a cohort of 1,022 patients who underwent polysomnography.⁸

This finding was substantially reinforced by Redline et al, followed 5,422 participants without a history of stroke for a median of 8.7 years and observed 193 incident ischemic strokes. Moderate to severe OSA was associated with a nearly three fold increase in stroke risk among men.¹⁰

These two independent cohort provide convergent primary study evidence for OSA as an independent stroke risk factor.

Pathophysiological Mechanism

Several pathophysiological pathways have been proposed to explain the relationship between inadequate sleep and increased stroke risk. Sleep deprivation is known to induce endothelial dysfunction through reduced nitric oxide (NO) bioavailability via impairment of the eNOS/NO/cGMP pathway, as demonstrated experimentally in a middle-aged rat model of REM sleep deprivation. This endothelial impairment reduces NO-dependent vasodilation and vascular compliance.²¹

Beyond the endothelial pathway, sleep deprivation has also been linked to hypertensive heart disease in a nationwide population-based cohort study, alongside increases in systemic inflammatory markers, excessive sympathetic activation with impaired baroreflex sensitivity, vasomotor imbalance, oxidative stress, metabolic disturbance, and dysregulation of vascular circadian clock genes.²¹

In OSA specifically, recurrent intermittent hypoxia during sleep triggers sympathetic nervous system activation, increased vascular resistance, systemic inflammation, and elevated catecholamine, angiotensin II, and endothelin-1 levels, which collectively contribute to hypertension, cardiovascular disease, and increased stroke risk. Repeated intrathoracic pressure swings and arousal events during apneic episodes further aggravate this autonomic and hemodynamic dysregulation.²¹

CONCLUSION

The evidence reviewed here supports a consistent, U/J-shaped association between sleep duration and stroke risk, with both short (<6 h/day) and long (>8-9 h/day) sleep consistently linked to higher stroke incidence and mortality across multiple large prospective cohorts, and the lowest risk observed around 7-7.5 hours per night. Poor sleep quality and continuity, whether assessed subjectively via instruments such as the PSQI or objectively through polysomnography and

actigraphy, independently add to this risk, and appear to interact additively with non-ideal sleep duration. Chronic insomnia is likewise associated with increased stroke risk, particularly among younger adults and those with persistent symptoms, while also emerging as a common post-stroke sequela, indicating a bidirectional rather than strictly unidirectional relationship. Among all sleep disturbances examined, obstructive sleep apnea shows the strongest and most mechanistically coherent association with stroke, independent of hypertension and other conventional cardiovascular risk factors.

Mechanistically, these associations are plausibly explained by endothelial dysfunction via impaired eNOS/NO/cGMP signaling, heightened sympathetic activation with reduced baroreflex sensitivity, systemic inflammation, oxidative stress, and disruption of vascular circadian regulation, with intermittent hypoxia in OSA further amplifying these pathways through recurrent autonomic and hemodynamic stress.

Despite this convergent epidemiological and mechanistic evidence, inadequate sleep should currently be regarded as a robust risk marker and a plausible, potentially modifiable risk factor, rather than a firmly established causal determinant. Further intervention studies and genetically informed analyses are needed to clarify causality and to determine whether correcting sleep duration, quality, or treating OSA and chronic insomnia can meaningfully reduce stroke incidence. In the meantime, given the consistency and strength of the observational evidence, routine screening for sleep disturbances, particularly OSA and chronic insomnia, warrants consideration as part of primary and secondary stroke prevention strategies.

REFERENCES

1. GBD 2021 Stroke Risk Factor Collaborators. Global, regional, and national burden of stroke and its risk factors, 1990–2021: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet Neurol.* 2024;23(10):973–1003.

2. Cheng Y, Ding Y, Elmadhoun A, Ji X, Geng X. The link between sleep duration and stroke risk. *Brain Circ.* 2025 Mar 21;11(1):1-8. doi: 10.4103/bc.bc_7_24. PMID: 40224552; PMCID: PMC11984815.
3. Phua CS, Jayaram L and Wijeratne T. 2017. Relationship between Sleep Duration and Risk Factors for Stroke. *Front. Neurol.* 8:392. doi: 10.3389/fneur.2017.00392
4. Ungvari, Z., Fekete, M., Lehoczki, A. *et al.* 2025. Inadequate sleep increases stroke risk: evidence from a comprehensive meta-analysis of incidence and mortality. *GeroScience* **47**, 4679–4695. <https://doi.org/10.1007/s11357-025-01593-x>
5. Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ.* 2021;372:n71.
6. Qureshi AI, Giles WH, Croft JB, Bliwise DL. Habitual sleep patterns and risk for stroke and coronary heart disease: a 10-year follow-up from NHANES I. *Neurology.* 1997;48(4):904–11.
7. Leppävuori A, Pohjasvaara T, Vataja R, Kaste M, Erkinjuntti T. Insomnia in ischemic stroke patients. *Cerebrovasc Dis.* 2002;14(2):90–97.
8. Yaggi HK, Concato J, Kernan WN, Lichtman JH, Brass LM, Mohsenin V. Obstructive sleep apnea as a risk factor for stroke and death. *N Engl J Med.* 2005;353(19):2034–41.
9. Chen JC, Brunner RL, Ren H, Wassertheil-Smoller S, Larson JC, Levine DW, et al. Sleep duration and risk of ischemic stroke in postmenopausal women. *Stroke.* 2008;39:3185–92.
10. Redline S, Yenokyan G, Gottlieb DJ, Shahar E, O'Connor GT, Resnick HE, et al. Obstructive sleep apnea-hypopnea and incident stroke: the Sleep Heart Health Study. *Am J Respir Crit Care Med.* 2010;182(2):269–77.
11. Ruiter Petrov ME, Letter AJ, Howard VJ, Kleindorfer D. Self-reported sleep duration in relation to incident stroke symptoms: nuances by body mass and race from the REGARDS study. *J Stroke Cerebrovasc Dis.* 2014;23:e123–132.
12. Wu MP, Lin HJ, Weng SF, Ho CH, Wang JJ, Hsu YW. Insomnia subtypes and the subsequent risks of stroke: report from a nationally representative cohort. *Stroke.* 2014;45(5):1349–54.

13. Song Q, Liu X, Zhou W, Wang X, Wu S. Long sleep duration and risk of ischemic stroke and hemorrhagic stroke: the Kailuan Prospective Study. *Sci Rep.* 2016;6:33664.
14. Kawachi T, Wada K, Nakamura K, Tsuji M, Tamura T, Konishi K, et al. Sleep duration and the risk of mortality from stroke in Japan: the Takayama Cohort Study. *J Epidemiol.* 2016;26(3):123–30.
15. Jiang J, Gan Z, Li Y, Zhao W, Li H, Zheng JP, et al. REM sleep deprivation induces endothelial dysfunction and hypertension in middle-aged rats: roles of the eNOS/NO/cGMP pathway and supplementation with L-arginine. *PLoS One.* 2017;12(8):e0182746.
16. Ji A, Lou H, Lou P, Xu C, Zhang P, Qiao C, et al. Interactive effect of sleep duration and sleep quality on risk of stroke: an 8-year follow-up study in China. *Sci Rep.* 2020;10:8690.
17. Zhou L, Yu K, Yang L, Wang H, Xiao Y, Qiu G, et al. Sleep duration, midday napping, and sleep quality and incident stroke: the Dongfeng-Tongji cohort. *Neurology.* 2020;94(4):e345–56.
18. Titova OE, Michaëlsson K, Larsson SC. Sleep duration and stroke: prospective cohort study and Mendelian randomization analysis. *Stroke.* 2020;51(11):3279–85.
19. Zhao B, Wu Y, Jin X, Yang L, Yang J, Ma X, et al. Objectively measured sleep characteristics and incidence of ischemic stroke: the Sleep Heart Health Study. *Nat Sci Sleep.* 2021;13:1485–94.
20. Hoepel SJW, Berghout BP, Luik AI, Ikram MK. Sleep and 24-h activity rhythms and the risk of stroke: a prospective cohort study. *Neuroepidemiology.* 2024;58(4):229–36.
21. Rissardo JP, Khalil I, Taha M, Chen J, Sayad R, Fornari Caprara AL. Sleep disorders and stroke: pathophysiological links, clinical implications, and management strategies. *Med Sci (Basel).* 2025;13(3):113.